Teledyne Report

For the Year 1978

The Aerospace Metals: Superalloys and Titanium

This Teledyne Report deals with the aerospace metals, two families of alloys that were developed in response to the needs of the aerospace industry. One family, the superalloys, consists of premium vacuum melted nickel base alloys that retain exceptional strength and corrosion resistance at temperatures approaching 2000°F. The other consists of titanium alloys that combine a high strength to weight ratio with excellent corrosion resistance.

Teledyne Allvac is one of the largest producers of superalloys in the United States, and is an important producer of titanium alloys as well. Teledyne Allvac is the only U.S. producer of both these groups of alloys with totally integrated production facilities from melting to forging and rolling, supported by a complete modern analytical laboratory for quality control.

Teledyne Report featuring subjects of particular interest from Teledyne activities is issued on a quarterly basis. Previous topics include:

Screw Threading:
Machine tools for industry.

Urban Waste:
Recovering energy and materials.

Aerial Mapping:
Applying advanced digital techniques.

The Water Pik Story:
Innovative consumer product designs.

Dental Health:
Instruments, supplies and equipment for the dentist.

Space Navigation:
Computers that guide space launches.

Analytical Instruments:
Chemical detection for industry.

1776-1976:
Technology then and now.

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Financial security and investment capital.

The Refractory Twins:
Producing tungsten and molybdenum.

The Instrument Makers:
Surveying instruments and optical encoders.

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Developments in small piston engines.

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Teaching young people marketable skills.

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Aircraft emergency escape systems.

Microelectronic Hybrids:
The step beyond integrated circuits.

The Energy Options:
Nuclear fuel versus coal.

Workman's Compensation:
Extending the coverage.

Drilling for Offshore Oil:
Getting the oil out.

The Search for Oil:
Finding new oil deposits.

High Speed Steels:
Premium alloys for machine tools.

Energy Crisis in the Computer Room:
Controlling power quality.

Raydist:
Super-precise radiolocation system.

Welding:
Advanced alloys for joining metals.

General Aviation Engines:
Piston power for aircraft.

Rubber:
Diverse products for automobiles and industry.

Loran:
Improved all-weather navigation system.

Seismology:
Instruments for understanding earthquakes.

Casting:
Precision production of metal parts.

AIDS:
Monitoring commercial aircraft performance.

Thermoelectrics:
Direct conversion of heat to electricity.

Thin Metals:
How they are made and used by industry.

The Reproduction of Music:
Speakers for high fidelity sound.

The Crowded Spectrum:
Technology of microwave traveling wave tubes.

Science and Cinematography:
Motion pictures for scientific analysis.

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Jets of Water for Dental Health:
The Water Pik Oral Hygiene appliance.

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Doppler radar for moon landings.

The Aerospace Metals

Superalloys that retain their strength and corrosion resistance at high temperatures, and titanium alloys that combine strength, light weight and corrosion resistance at lower temperatures were developed in response to aerospace needs. Aerospace is still the largest user, but other industries are catching on fast.

Technology begets technology. This is particularly true in the material sciences, where basic knowledge and understanding of a certain class of materials has often made possible an entirely new industry. A good example of this was the development of the transistor from basic research in semiconductor materials. Ultimately this discovery led to a whole family of electronic semiconductor devices that revolutionized electronics, made the modern electronic computer a practical reality, and changed human society considerably.

Another equally revolutionary innovation was the development of the technology and machinery that made powered, man-carrying aircraft and spacecraft a reality. In this case, the basic invention came first, and then the material sciences were called upon to develop new and better materials, such as high strength aluminum alloys, that would replace the original wood, fabric and wire of the earliest aircraft. Even relatively recent inventions, such as the jet engine, stimulated great advances in the most basic of all materials sciences, metallurgy.

The jet aircraft engine, for example, is a gas turbine engine that derives its power from hot expanding gases. It operates more efficiently as the temperature of the gases that spin its turbine is increased. At some point the temperature of the gas is limited by the ability of the turbine blades to withstand that heat without yielding or melting. The problem is critical because the turbine blades are subjected to tremendous centrifugal forces at the same time they are heated to a high temperature. Corrosion resistance at high temperatures is also a major consideration.

When the jet engine was first being developed, in the late 1930's and the 1940's, its performance was severely limited by materials that lost much of their strength at temperatures not far over 1000°F. This limitation spurred intense research in the development of new metal alloys with better high temperature strength. The result is a modern family of alloys, usually referred to as superalloys, that retain exceptional strength and corrosion resistance at temperatures approaching 2000°F. At these temperatures copper melts, magnesium boils and steel becomes as pliable as common solder. The development of superalloys has made possible the tremendously powerful engines used in today's high performance jet aircraft.

On the Cover: The shape of a modern high-performance jet aircraft superimposed on a picture of hot superalloy ingots symbolizes the high temperature requirements that many aerospace alloys must meet.

Aerospace needs also gave rise to another family of important metal alloys. These are the titanium alloys that combine high strength with light weight and excellent corrosion resistance. They bridge the gap between the lighter but weaker aluminum and magnesium alloys and the stronger but heavier steels. These alloys offer considerable strength and excellent corrosion resistance up to about 900°F and are widely used in the cooler compressor section of jet engines, as well as for many structural parts including high-strength fasteners used in fabricating aircraft.

Superalloys and titanium alloys can be referred to as the aerospace metals because of the circumstances of their development and their widespread use in this industry. Their useful properties have not gone unnoticed by other industries, however, and their use in non-aerospace applications is growing rapidly.

Teledyne Allvac is one of the largest producers of superalloys in the United States, and is an important producer of titanium alloys as well. Teledyne Allvac, in fact, is the only totally integrated U.S. producer of both superalloys and titanium alloys with complete processing facilities from vacuum induction melting, vacuum consumable arc remelting, and electroslag remelting, to forging, blooming and bar mill facilities with a complete modern analytical laboratory to support these capabilities. This report details the company's activities in producing these alloys.

WHAT'S A SUPERALLOY?

Steel was the classic high strength material for building machines and engines until the advent of turbine engines. Special stainless steels were first developed to withstand high temperature corrosion encountered in steam turbines. Even the best of these, however, were found inadequate for use in the harsh high temperature environment of the gas turbine. Their strength falls off rapidly at temperatures above 1000°F and they are unable to withstand the corrosive conditions encountered in this kind of service.

Early jet engines operating at turbine inlet temperatures of about 1300°F produced only about one pound of thrust for each pound of engine weight. Modern commercial jet engines achieve five or six pounds of thrust per pound of weight, and the most advanced military engines achieve ratios of about eight to one. These advances were achieved by increasing turbine inlet temperatures to 2400°F or more as metallurgical and design advances permitted.

One of the first superalloys designed specifically for high temperature use was produced in 1943 and 1944 for use in making turbosupercharger buckets for the U.S. B-17 and B-25 aircraft. It was an air melt alloy suitable for service to about 1500°F. The modern vacuum melting technique of producing these alloys (that Teledyne Allvac currently uses) to achieve exceptional purity and uniformity was not introduced commercially until the early 1950's.

Modern superalloys are compounded with nickel as the basic ingredient and are consequently also known as nickel-base alloys. Of the nickel-base alloys that Teledyne Allvac routinely produces, nickel content ranges from about 40 to 88 percent with most alloys having a nickel content in the 50 to 60 percent range. Few of these alloys have any appreciable iron content.

The other major ingredients are chromium which may typically be in the 15 to 20 percent range, cobalt typically in the 10 to 20 percent range, and molybdenum in the 5 to 10 percent range. There are dozens of different formulations, each for a specific alloy with its own unique properties.

Each alloy produced by Teledyne Allvac may be compounded of as many as nine different alloying ingredients, each in carefully measured percentages, with some critical ingredients controlled to within a thousandth of a percent by weight. In addition to nickel, chromium, cobalt and molybdenum, other alloying elements may include aluminum, boron, carbon, columbium (niobium), iron, tantalum, titanium, tungsten, vanadium and zirconium. Each of these elements imparts some specific desirable metallurgical property to the alloy.

Aluminum, titanium and columbium, for example, form the basic strengthening phase, gamma prime, which imparts strength up to about 1500°F. Molybdenum and tungsten are solid solution hardening elements that are effective in strengthening the alloy at higher temperatures. Cobalt increases the gamma prime solvus temperature effectively increasing strength at higher temperatures, and some believe that it also contributes to better hot workability of the alloy. Chromium contributes corrosion resistance, and boron and zirconium improve creep properties, life and ductility under long term high temperature stress.

PRODUCING SUPERALLOYS

Because superalloys are used in critical, high-stress applications, they must be formulated with great precision and produced under unusual conditions of cleanliness and purity. The process begins with careful analysis and control of the raw materials used and continues with frequent analyses and inspections at specific points in the production process. These quality assurance evaluations include mass and X-ray spectrography, wet chemical analysis, metallographic inspection, ultrasonic and dye penetrant inspection for physical flaws, and mechanical testing for tensile properties and stress-rupture life at elevated temperatures.

The melting process itself is designed to assure the greatest possible purity and uniformity of each batch of alloy produced. Many common metals and alloys are melted in air with the molten metal only partially protected by a thin layer of slag that floats on its surface. Gases such as oxygen, hydrogen and nitrogen can dissolve in molten metal, combine with some of the more active ingredients and degrade the valuable properties of the finished alloy.

DOUBLE VACUUM MELTING

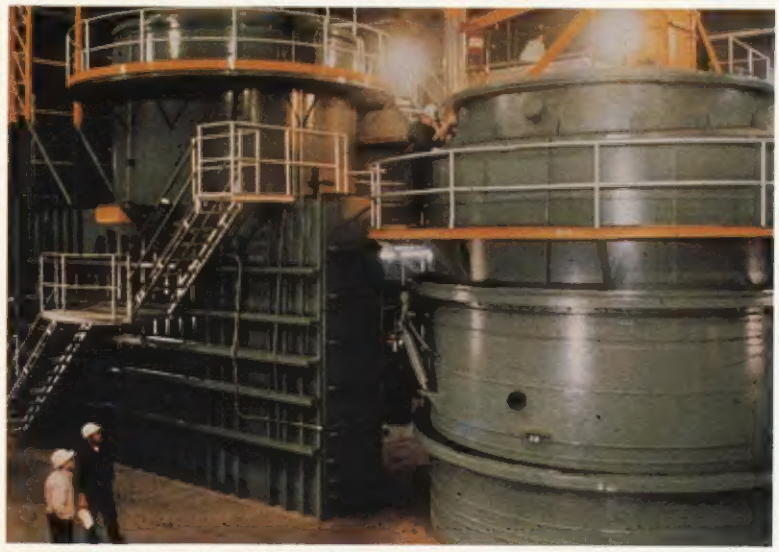
Contamination is avoided in the production of most superalloys by carrying out all melting operations under vacuum conditions. The first step in this process is preparing the basic alloy in a vacuum induction furnace. Up to eleven tons of raw material are put into a refractory crucible and melted by electrical induction from large electrical coils that surround the crucible. The strong magnetic fields produced by the induction coils also stir the molten metal continuously.

The entire melting apparatus, as well as the molds into which the metal will be cast, are encapsulated in a vacuum chamber about 40 feet tall and 20 feet in diameter. During a melt this chamber is pumped down to a vacuum that contains less than one part of air in 75,000. Since the molten alloy is held in this chamber for up to twelve hours and stirred constantly by the magnetic fields, every portion of the entire batch of metal is exposed to high vacuum which helps boil out and draw off certain gaseous impurities. To assist this process, excess carbon is added with the basic charge. The carbon combines with residual oxygen in the raw materials to form the gas carbon monoxide which is drawn off by the vacuum pumps.

Superalloys

3: The finished alloy is poured into molds inside the vacuum chamber of the furnace to form electrodes for the second step in the process. Here a cooled superalloy electrode is removed from its mold.

1: The first step in producing precision superalloys is melting the carefully measured ingredients under high vacuum in one of these 40-foot tall vacuum induction furnaces.

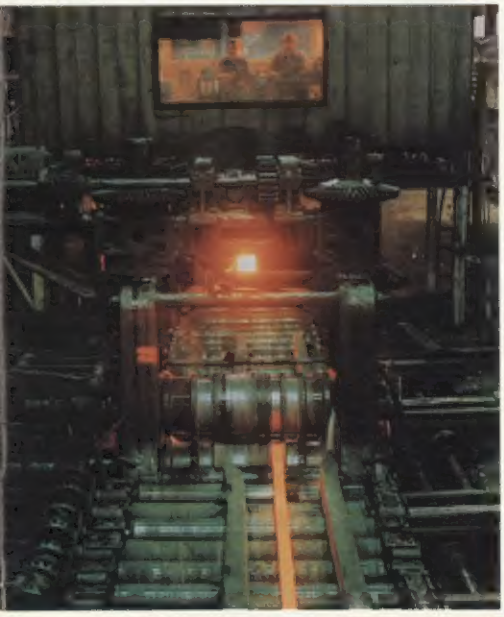


2: Up to eleven tons of alloy may be melted in this induction heated crucible. The magnetic field stirs the molten metal exposing every part of it to high vacuum degassing.

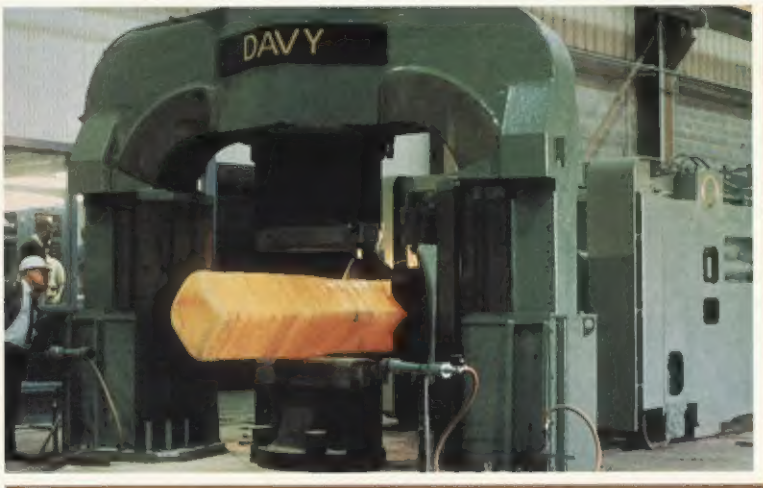
4: Each superalloy electrode is remelted, again under high vacuum, for further degassing in a consumable electrode vacuum arc furnace. The electrode is seen being lowered into a water cooled copper crucible.

5: An alternate method of remelting is the electroslag or ESR process shown here. The same type of electrode is used, but is melted under a thick protective blanket of special molten slag instead of under vacuum. The process has advantages for certain types of alloys.

6: Four completed superalloy ingots are brought to proper temperature for hot working into mill products in this soaking furnace. They must be maintained within a few hundred degrees of a specific temperature during the reduction process.



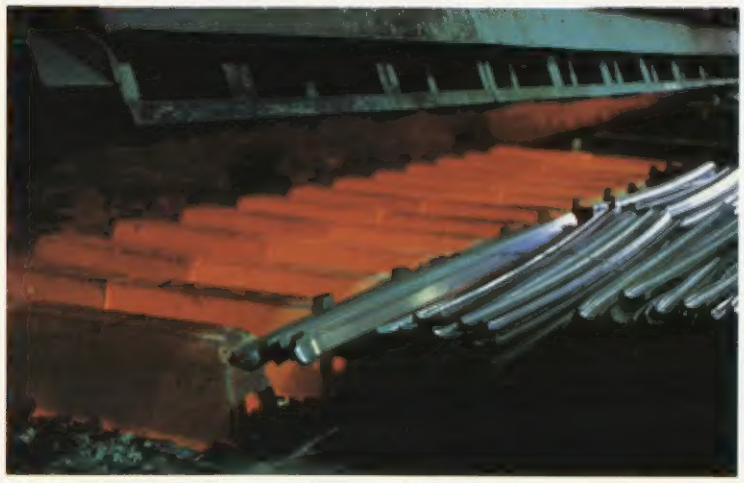
8: Forged billets or small ingots are reduced to smaller and smaller cross section as they are passed back and forth between the rolls of this blooming mill. A barrel furnace, seen glowing at the rear, is used to reheat the billet when its temperature reaches the lower end of the working range.



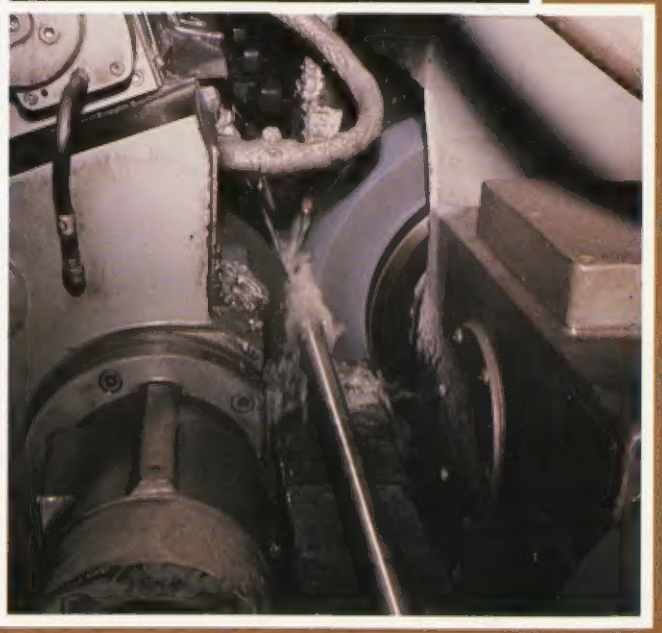
7: This superalloy ingot is in the process of being forged to smaller dimensions on Teledyne Allvac's 3500-ton forging press. Superalloys may be sold to customers as forged billets, or further reduced in size to other mill products.

10: Further reduction in size and conversion to round, square, flat or specially-shaped bar is carried out on bar mills such as this one. The hot bar is passed back and forth through a series of smaller and smaller rolls until it reaches the proper size and shape.

9: Surface defects are removed from ingots and billets by grinding before they are processed further. This large grinding machine moves back and forth on tracks as an operator in the air conditioned cab guides the grinding wheel along the surface of the metal.



11: Precise heat treatment is essential to achieve the proper metallurgical properties in the finished product. Here, a batch of finished superalloy bar is being loaded into a heat treating furnace.



12: Round superalloy bar and rod is frequently centerless ground to provide the customer with a ready-to-use finished product for certain applications.

Vacuum locks on the furnace permit the highly reactive constituents of the alloys such as aluminum, zirconium, titanium and boron to be added late in the melting cycle. These "late additions" dissolve in the molten metal without interference from impurities to create precipitation hardening phases which impart excellent high temperature properties to the alloy. Through these same vacuum locks small in-process samples of the melt can be taken for chemical analysis and correction of any deviations before the batch is finished.

When chemical analysis has determined that the melt has reached the proper specifications for the alloy being produced, the molten metal is transferred to a teeming ladle within the vacuum chamber. The molten alloy then flows from the ladle into a series of metal molds also in the vacuum chamber.

The castings which are produced in this first vacuum melting of the alloy are up to 30 inches in diameter and eight feet long, and weigh up to ten tons. They are called electrodes because this will be their function in the second step of the double melting process that is carried out in a consumable arc furnace.

VACUUM CONSUMABLE ARC REMELT

In the second step of the double vacuum melt process, the electrode is lowered into a vertical water-cooled copper crucible that is just a few inches greater in diameter than the electrode itself. The electrode is held at its top end by a hydraulic mechanism that allows it to be raised or lowered with great precision. This entire apparatus is enclosed in a vacuum-tight housing. The inner chamber is pumped out to a high vacuum and a high amperage electrical power supply is energized. One side of this power source is connected to the copper crucible and the other to the electrode. When the electrode is lowered so that it touches the bottom of the crucible and withdrawn slightly, an electrical arc is started between the two. This arc melts the metal from the tip of the electrode. The molten droplets of metal that are produced are again subjected to a high vacuum for a final and thorough outgassing. During the process, which takes up to twelve hours, the electrode is consumed and the molten metal resolidifies in the water-cooled copper crucible which also acts as a mold. The entire process is closely analogous to the melting of a welding electrode and the resolidification of the metal on a workpiece.

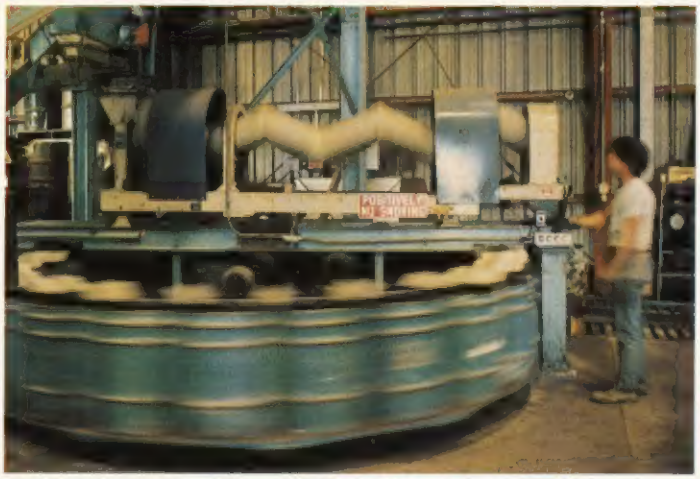
Close control of the melting voltage and current produces consistently high quality superalloy ingots weighing from 3000 to 20,000 pounds. Ingots produced by this vacuum consumable arc process have excellent grain structure, minimum pipe and extremely low gas content that is vital to high strength properties and optimum processing yields.

ELECTROSLAG REMELT

Double vacuum melting of superalloys is a very reliable process that is at the pinnacle of metallurgical melting techniques from the standpoint of cleanliness, consistency and quality of the end product. There are, however, certain non-vacuum melting processes which are suitable and even advantageous for the production of certain types of superalloys. One of these is the electroslag remelt or ESR process. In this process an electrode produced in the vacuum induction furnace is remelted in a progressive manner just as in the vacuum consumable process. In this case, however, the electrode and remelted metal are protected from contact with air by a thick blanket of specially prepared slag material instead of by a vacuum. Heat is generated by resistance to current passage through the slag rather than by an arc. The process can

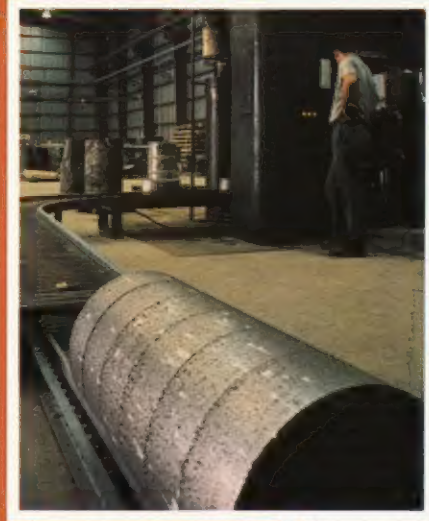
Titanium

1: Crushed titanium sponge and other alloying ingredients such as aluminum and vanadium are carefully blended in this carousel-type blender to assure uniform dispersion of the alloy elements throughout the titanium.



2: The blended ingredients are then compressed into briquets about 5 inches thick and 16 inches in diameter, on this large hydraulic press.

4: Some titanium revert material, lathe turnings, punch press scrap and small rejected parts are remelted in a skull furnace. The Teledyne Allvac Telecast process, shown here, permits this material to be melted under a partial pressure of argon gas in small batches and consolidated into a cast electrode.



3: (Above, center) The compacted titanium sponge briquets are welded together to form an electrode, typically 12 feet long, in this plasma arc welding machine. Welding is done under a partial pressure of inert argon gas to maintain the purity of the alloy.

6: A 26-inch titanium ingot is shown here being removed from the copper crucible/mold in which it was formed by the vacuum arc process. After cooling and a series of quality assurance inspections it may be further reduced into a variety of titanium mill products.

5: As in the production of superalloys, most titanium alloys undergo two separate vacuum melting processes. In the case of titanium, both melts are done in a vacuum arc consumable furnace. Operator here monitors the arc projected on a screen by optical methods.

produce a better surface finish on ingots of certain alloys that have a volatile component. This better surface finish means a greater yield of usable alloy from the ingot when it is further reduced by various mill processes. In some cases it is also possible to get a certain amount of desulfurization of alloys that may be contaminated with this element.

MAKING SUPERALLOY MILL PRODUCTS

Conversion of superalloy ingots into finished billet, bar, rod and special shapes is also a critical operation. The ingots are brought to a high, uniform temperature, typically in the 1700 to 2150°F range, to prepare them for further working. The working temperature must be maintained within close limits during the rolling process to assure that the finished product will have the desired metallurgical structure. For some alloys such as Allvac Astroloy, the rolling temperature must be held within an exceptionally narrow range.

The larger ingots are reduced on a 3500-ton forging press to either finished customer billet or internal reroll billet. The reroll billet is then further reduced on a blooming mill to square bar in the 6 to 2⅝ inch range. Further reduction steps may involve hot rolling to smaller bar, rod or complex shapes.

Superalloys may be sold in virtually any of the forms mentioned: ingot, billet, bar, rod, shapes, or even wire. At the end of each reduction step the product is inspected and any defects in the surface finish are ground away before further reduction takes place. Ultrasonic inspection is used to detect internal flaws and dye penetrant inspection checks for surface defects.

Since the many different alloys produced look identical, great care is taken to assure the identity of each piece and its traceability to the original melt as it is processed. Each piece produced is also finally checked for alloy verification by X-ray techniques. The other chemical, metallographic and mechanical tests mentioned earlier are carried out for each lot produced in accordance with specification requirements.

TITANIUM

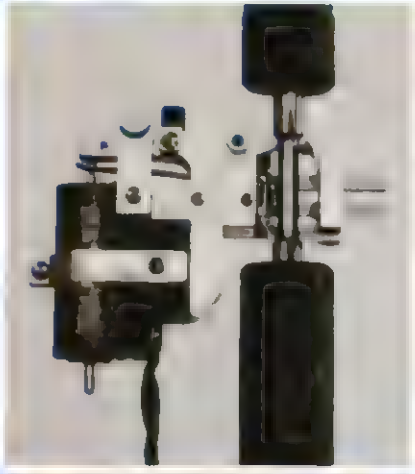
Titanium is a valuable aerospace material because of its high strength to weight ratio and its corrosion resistance. Its corrosion resistance also makes it a valuable metal for non-aerospace uses, particularly in the chemical industry where it is used to fabricate reaction vessels, valves, piping and fixtures of all sorts. Though titanium is one of the earth's most abundant elements, it has only been produced in large quantities in recent times due to aerospace demands.

One reason titanium did not find wider use earlier is the difficult and expensive process required to refine it. The common ore is rutile, a mineral that contains the oxide form of titanium. It is mined chiefly in Australia. Extracting the metal from the ore involves a complex series of chemical steps known as the Kroll process. This is the same process used in extracting zirconium from its ore. (See Teledyne Report for the year 1974.) In simplified form this process involves reacting the ore with chlorine gas at an elevated temperature to produce titanium tetrachloride. This liquid is then reacted in a closed vessel with magnesium or sodium metal to produce titanium sponge with magnesium or sodium chloride as a waste product. The sponge may then be used for the production of titanium alloys. Better quality sponge that is less contaminated by residual chloride is made by vacuum distilling the original sponge product.

Quality Control

1: Each batch of alloy is analyzed to confirm that it meets the exact chemical composition specified. This x-ray fluorescence unit is capable of measuring 16 elements simultaneously.

2: Mechanical properties of the finished alloys are determined by a variety of tests, including this tensile test. The precisely machined sample, with the narrowed center section, is subjected to a slowly increasing tension until it ruptures. Instrumentation measures the yielding of the test piece during the process.



3: Metallographic analysis is used to determine the structure of a sample taken from each lot of alloy produced. Microscopic examination of the grain structure of an etched and polished sample of the metal shows whether or not the various hot working and heat treatment processes were carried out properly.

5: Surface flaws in centerless ground products, undetectable to the unaided eye, are brilliantly exposed using a dye penetrant inspection. Any flaws glow brilliantly under ultraviolet light as yellow-green spots.

4: Teledyne Allvac's centerless ground rod products are subjected to ultrasonic inspection to detect any internal flaws. The operator is alerted to these by both a visual indication on a cathode ray tube and an audible alarm.

PRODUCING TITANIUM ALLOYS

The production of precision titanium alloys from titanium sponge begins with a blending operation to combine the crushed and graded sponge material with the other alloying ingredients which may include aluminum, vanadium, tin and molybdenum. This careful blending of titanium alloy raw materials is necessary prior to melting since the titanium melt processes do not permit complete mixing of the entire heat in the molten state as is accomplished during the melting of superalloys.

The blended material is then weighed out into batches of about 125 pounds each. This amount of material is placed in a die cavity and compressed by a 3500-ton hydraulic press which compacts the material into disc-shaped briquets about 5 inches thick and 16 inches in diameter.

These briquets are then welded together to form an electrode about 12 feet long that will be used in the subsequent vacuum consumable arc melting process. This welding is done by a plasma arc method in a large chamber filled with an argon atmosphere.

A considerable amount of titanium is also produced from revert material that has been recycled from the aerospace industry and other sources. This scrap material is analyzed for its alloy content on a piece by piece basis using X-ray spectrography. The pieces are then carefully welded together to form electrodes for consumable arc melting.

Some revert material such as stamping scraps, lathe turnings and small rejected parts are too small to be welded together economically. Teledyne Allvac developed a technique known as the Telecast process that permits this material to be reduced to electrode form in a rapid and efficient manner.

The Telecast process uses a non-consumable copper electrode to melt the revert material in a small water-cooled copper crucible under a partial pressure of argon gas. Additional revert is added to this crucible in small quantities under the remote control of an operator who can observe the process through an optical viewing system. At intervals, the molten metal that has accumulated in the crucible is poured into an electrode mold that is also in the argon chamber. In this way, small quantities of revert material are melted and combined to form a large homogeneous electrode.

The finished electrodes produced by any of the above processes are then remelted in a vacuum consumable arc furnace to produce ingots 26 to 34 inches in diameter, weighing up to 5 tons.

TITANIUM MILL PRODUCTS

The reduction of titanium ingots to various mill products is very similar to the mill processes used for superalloys. Titanium ingots must be reduced in size on the forging press; the billet may be further reduced on a blooming mill and bar mills to produce a variety of bar products and coiled wire. The wire is then cold drawn for use as aerospace fastener stock.

Teledyne Allvac produces commercially pure titanium which is widely used in the chemical industry because of its corrosion resistant properties. Titanium has outstanding resistance to salt water corrosion and has been highly successful in industrial cooling systems that use brackish or sea water, as well as in desalination plants. It also resists attack by hydrogen sulfide, high pressure steam, ammoniated solutions and other chemicals.

For most aerospace applications, however, greater strength is achieved with various alloys. Teledyne Allvac produces about a half dozen standard titanium alloys and also custom alloys made to special customer formulation.

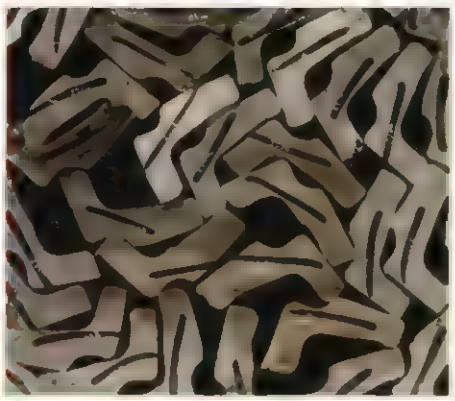
The most popular titanium alloy produced by Teledyne Allvac is Allvac 6AL-4V

Products

1: This 30-inch diameter 5-ton titanium ingot is the end product of Teledyne Allvac's titanium melt shop. Some titanium is sold to customers in this form but most is reduced to smaller forms by forging, blooming, rolling and/or drawing processes.

2: These 10-inch diameter superalloy billets are ready for final inspection. Billet is one of the largest selling products in the Teledyne Allvac line.

3: Billet may be forged to special shapes to meet specific production requirements. These 12-inch octagonal superalloy billets were made to customer order.



5: Centerless ground superalloy rod is produced in a great variety of diameters. The fine surface finish and right quality control assure the user of a premium quality product. Color coding identifies the specific alloy content of the material.

4: Complex hot-rolled superalloy shapes such as these are widely used in the fabrication of jet engine parts. By being made close to the required net shape of the end product, machining costs and waste are reduced.

6: Titanium alloys, such as Allvac 6AL-4V, are frequently reduced to wire form by drawing the material through successively smaller dies until the exact final diameter is achieved. This material is widely used by the aerospace industry for manufacturing titanium aircraft fasteners such as bolts and rivets.

which contains six percent aluminum and four percent vanadium with the balance titanium. The aluminum is added to increase the strength of titanium while the vanadium addition improves ductility and permits the alloy to be strengthened by thermal treatment. The result is a versatile, high-strength titanium alloy that can be used over a broad range of temperatures from cryogenic to about 800°F. This alloy is typically used in compressor blades, discs and rings for jet engines, airframe and space capsule components, pressure vessels, rocket engine cases, helicopter rotors, fasteners and critical forgings that require a high strength to weight ratio.

MARKETS FOR THE AEROSPACE METALS

Superalloys and titanium are still aerospace metals, but only by a small margin. The aerospace or jet engine market, for example, accounts for only slightly more than half of superalloy production today. The use of titanium in non-aerospace applications is also growing faster than it is for aerospace uses, and it is projected that the 50 percent mark will be crossed not too far in the future.

A large and growing market for superalloys lies in non-aerospace gas turbines that are being used in increasing numbers for power generation, marine propulsion, heavy tank, truck and earth-moving equipment engines, and power sources for industrial processes.

The same high temperature strength and low corrosion properties needed in gas turbines are making superalloys useful in valves, pumps, heat exchangers, condensers and process vessels used in chemical, petroleum, pulp and paper and high temperature industrial processes of all sorts. The nuclear industry, specifically for reactors used on board ships, takes advantage of superalloy properties for the required long-term dependability. Automotive turbocharger turbines and exhaust valves for diesel engines are also growing applications. Many new energy production schemes such as coal liquifaction, geothermal wells and fusion, offer myriad needs for metals with high temperature strength and exceptional corrosion resistance.

In addition to the conventional superalloys Teledyne Allvac also melts some iron base alloys for specialized applications including core components for advanced nuclear reactors, missile cases, engine shafts and other critical components. Most of these applications specify vacuum melting in order to obtain the optimum in cleanliness and compositional control. Products supplied range from large diameter bar and billet to wire less than 1/16 inch in diameter. Alloys in this category include 316 stainless steel as well as 250 and 300 maraging steel.

The American Iron and Steel Institute estimates that 1978 U.S. production of vacuum melted superalloys was 64 million pounds. This is about double the U.S. production in 1967.

The non-aerospace uses of titanium follow closely the uses of superalloys. Here neither the strength nor the temperature capability need be quite as high, but titanium's exceptional corrosion resistance to a variety of rather harsh chemicals is of great importance.

The U.S. Department of Commerce reported 1977 U.S. production of titanium ingot at 53 million pounds. This is about what it was in 1967, though production has varied widely in the intervening years in response to fluctuating aerospace demand. The broader base of non-aerospace applications that are developing promises to stabilize the market.

Superalloys and titanium, born out of the needs of the aerospace era, are now making many other technologies more practical.

Letter to Shareholders:

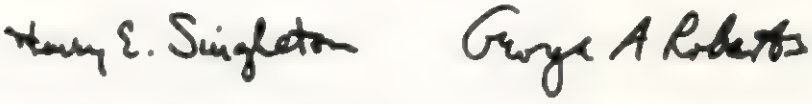
Teledyne's net income for the year ended December 31, 1978 rose to $248.5 million from $194.8 million in 1977. Earnings per share in 1978 were $19.13 compared to $14.81 in 1977. Sales of consolidated companies were $2.44 billion, up from last year's $2.21 billion.

For the fourth quarter of 1978 net income was $88.1 million, or $6.88 per share, compared to last year's fourth quarter net of $64.3 million, or $4.90 per share. Consolidated fourth quarter sales rose to $654 million in 1978 from $589 million in 1977.

The use of equity accounting for certain investments of unconsolidated subsidiaries decreased 1978 net income $16.9 million or $1.31 per share, compared to an increase in 1977 net income of $11.1 million or $0.85 per share. In the fourth quarter, the effect of equity accounting was to increase net income $3.3 million or $0.26 per share in 1978 and $2.8 million or $0.22 per share in 1977.

Revenue and net income by business segment are shown on page 34 of this report. Management's Discussion and Analysis of Summary of Operations is given on page 33. Each of our business segments except Consumer products set new records in sales and net income. The Insurance and Finance group showed an especially significant gain. Results in Specialty Metals also improved substantially, and some of Teledyne's activities in this area are featured in this report.

The year 1978 was the best ever for Teledyne in sales, net income and earnings per share.



Chairman of the Board of Directors

President

Consolidated Statements of Income

For the Years Ended December 31, 1978 and 1977

	1978	1977
Consolidated Sales	$2,441,629,000	$2,209,731,000
Consolidated Costs and Expenses:		
Cost of sales	1,805,657,000	1,624,913,000
Selling and administrative expenses	279,335,000	267,827,000
Interest expense (Notes 4 and 9)	15,843,000	16,990,000
Interest and dividend income	(16,756,000)	(11,636,000)
Provision for income taxes (Note 8)	181,600,000	159,800,000
	2,265,679,000	2,057,894,000
Income of Consolidated Companies	175,950,000	151,837,000
Equity in Net Income of Unconsolidated Subsidiaries, after allocated interest expense and income tax items (excludes equity in unrealized appreciation on marketable equity securities of $13,241,000 in 1978 and unrealized depreciation of $23,628,000 in 1977) (Notes 4 and 9)	72,553,000	42,946,000
Net Income	$ 248,503,000	$ 194,783,000
Net Income Per Share (Note 2)	$19.13	$14.81

Consolidated Statements of Retained Earnings

For the Years Ended December 31, 1978 and 1977

	1978	1977
Balance, Beginning of Year, as previously reported	$ 667,694,000	$ 496,265,000
Effect on prior year of equity accounting (Note 14)	701,000	—
As restated	668,395,000	496,265,000
Net income	248,503,000	194,783,000
Fair value of common stock dividends (Note 5)	(116,170,000)	(20,914,000)
Redemption of $6 series preferred stock (Note 5)	(12,742,000)	—
Cash dividends on preferred stock	(387,000)	(1,739,000)
Balance, End of Year	$ 787,599,000	$ 668,395,000

The accompanying notes are an integral part of these statements.

Consolidated Balance Sheets

December 31, 1978 and 1977

Assets

	1978	1977
Current Assets:		
Cash	$ 43,691,000	$ 44,668,000
Marketable securities, at cost which approximates market	218,957,000	242,300,000
Receivables, less reserve of $10,492,000 in 1978 and $10,820,000 in 1977	283,978,000	252,445,000
Inventories (Note 3)	167,686,000	161,167,000
Prepaid expenses	4,653,000	6,006,000
Total current assets	718,965,000	706,586,000
Investments in Unconsolidated Subsidiaries (Note 9):		
Life insurance companies	290,410,000	252,848,000
Casualty insurance companies	227,820,000	182,908,000
	518,230,000	435,756,000
Property and Equipment, at cost (Note 4):		
Land	17,036,000	16,950,000
Buildings	113,495,000	113,120,000
Equipment and improvements	482,316,000	401,434,000
	612,847,000	531,504,000
Less accumulated depreciation and amortization	328,377,000	287,861,000
	284,470,000	243,643,000
Other Assets:		
Cost in excess of net assets of purchased businesses (Note 9)	30,276,000	30,795,000
Other	5,049,000	6,977,000
	35,325,000	37,772,000
	$1,556,990,000	$1,423,757,000

The accompanying notes are an integral part of these balance sheets.

Liabilities

	1978	1977
Current Liabilities:		
Accounts payable	$ 109,054,000	$ 96,733,000
Accrued liabilities	166,067,000	147,741,000
Accrued income taxes (Note 8)	61,300,000	105,900,000
Current portion of long-term debt (Note 4)	21,239,000	5,192,000
Total current liabilities	357,660,000	355,566,000
Long-Term Debt (Note 4)	261,695,000	313,350,000
Deferred Income Taxes (Note 8)	61,600,000	58,300,000
Other Long-Term Liabilities	10,356,000	10,066,000
Commitments and Contingencies (Note 6)		
Shareholders' Equity:		
Preferred stock (Note 5)	—	516,000
Common stock (Note 5)	32,340,000	32,340,000
Additional paid-in capital	512,659,000	445,885,000
Retained earnings (Note 4)	787,599,000	668,395,000
Equity in unrealized depreciation on marketable equity securities of unconsolidated subsidiaries (Note 9)	(276,000)	(3,066,000)
	1,332,322,000	1,144,070,000
Less treasury stock, at cost (Note 5)	466,643,000	457,595,000
Total shareholders' equity	865,679,000	686,475,000
	$1,556,990,000	$1,423,757,000

Consolidated Statements of Changes in Financial Position

For the Years Ended December 31, 1978 and 1977

	1978	1977
Working Capital was Provided by:		
Net income	$248,503,000	$194,783,000
Equity in net income of unconsolidated subsidiaries before allocated interest expense and income tax items (Note 9)	(77,688,000)	(32,713,000)
Depreciation and amortization of property and equipment	57,236,000	48,239,000
Other amortization and charges not affecting working capital	3,418,000	2,532,000
Change in deferred income taxes	3,300,000	(7,500,000)
Working capital provided from operations	234,769,000	205,341,000
Increase in long-term debt	25,617,000	7,804,000
Dispositions of property and equipment	3,956,000	2,766,000
Issuance of common stock for the exercise of warrants and for employees' stock option plan	3,065,000	1,014,000
	267,407,000	216,925,000
Working Capital was Applied to:		
Additions to property and equipment	102,019,000	60,404,000
Reduction in long-term debt	79,159,000	11,205,000
Acquisition of treasury stock	64,868,000	—
Redemption of preferred stock	5,629,000	—
Investments in and advances to unconsolidated subsidiaries	1,996,000	71,588,000
Dividends on preferred stock	387,000	1,739,000
Other, net	3,064,000	(5,532,000)
	257,122,000	139,404,000
Increase in Working Capital	$ 10,285,000	$ 77,521,000
Working Capital Increase (Decrease):		
Cash	$ (977,000)	$ 2,412,000
Marketable securities	(23,343,000)	51,918,000
Receivables	31,533,000	41,321,000
Inventories	6,519,000	16,893,000
Prepaid expenses	(1,353,000)	(408,000)
Accounts payable	(12,321,000)	(844,000)
Accrued liabilities	(18,326,000)	(15,488,000)
Accrued income taxes	44,600,000	(17,800,000)
Current portion of long-term debt	(16,047,000)	(483,000)
	$ 10,285,000	$ 77,521,000

The accompanying notes are an integral part of these statements.

Consolidated Statements of Capital Stock, Additional Paid-In Capital and Treasury Stock

For the Years Ended December 31, 1978 and 1977

	Preferred Stock ($1 Par Value)	*Common Stock ($1 Par Value)*	*Additional Paid-In Capital*	*Treasury Stock*
Balance, December 31, 1976	$516,000	$32,340,000	$432,360,000	$466,007,000
Stock issuance:				
Common stock dividend (342,836 shares)	—	—	13,633,000	(7,290,000)
Exercise of stock options (48,172 shares)	—	—	(200,000)	(1,023,000)
Exercise of warrants (4,393 shares)	—	—	96,000	(95,000)
Conversion of $6 series preferred stock (212 common shares issued)	—	—	(4,000)	(4,000)
Balance, December 31, 1977	516,000	32,340,000	445,885,000	457,595,000
Stock issuance:				
Common stock dividend (1,198,577 shares)	—	—	89,280,000	(25,484,000)
Conversion of $6 series preferred stock (312,613 common shares issued – Note 5)	(234,000)	—	(6,441,000)	(6,646,000)
Exercise of warrants (78,995 shares)	—	—	1,258,000	(1,797,000)
Exercise of stock options (583 shares)	—	—	(3,000)	(13,000)
Redemption of $6 series preferred stock (282,149 shares, including retirement of 225,912 shares held in treasury – Note 5)	(282,000)	—	(14,485,000)	(21,880,000)
Acquisition of common stock (722,150 shares)	—	—	—	64,868,000
Purchase of warrants	—	—	(2,835,000)	—
Balance, December 31, 1978	$ —	$32,340,000	$512,659,000	$466,643,000

The accompanying notes are an integral part of these statements.

Auditors' Report

To the Shareholders and
Board of Directors, Teledyne, Inc.:

We have examined the consolidated balance sheets of Teledyne, Inc. (a Delaware corporation) and subsidiaries as of December 31, 1978 and 1977, and the related statements of income, capital stock, additional paid-in capital and treasury stock, retained earnings and changes in financial position for the years then ended. Our examinations were made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. The consolidated financial statements of Unicoa Corporation and subsidiaries were examined by other auditors whose reports thereon have been furnished to us. Our opinion expressed herein, insofar as it relates to the amounts included for Unicoa Corporation and subsidiaries, is based solely upon the reports of the other auditors. Teledyne's investment in Unicoa was 19 percent in 1978 and 18 percent in 1977 of consolidated assets and its equity in Unicoa's net income, after allocated interest expense and income tax items as described in Note 9, was 15 percent in 1978 and 7 percent in 1977 of consolidated net income.

In our opinion, based upon our examinations and the reports of other auditors referred to above, the accompanying consolidated financial statements present fairly the consolidated financial position of Teledyne, Inc. and subsidiaries as of December 31, 1978 and 1977, and the results of their operations and changes in their financial position for the years then ended, in conformity with generally accepted accounting principles consistently applied during the periods.

ARTHUR ANDERSEN & CO.

Los Angeles, California,
January 10, 1979.

Notes to Consolidated Financial Statements

(1) Summary of Significant Accounting Policies. *Principles of Consolidation.* The consolidated financial statements of Teledyne, Inc. include the accounts of all its subsidiaries except its insurance and finance subsidiaries. The investments in unconsolidated subsidiaries, which include advances, are accounted for by the equity method. All material intercompany accounts and transactions have been eliminated.

Currency Translation. All assets and liabilities of foreign subsidiaries and other foreign currency assets and liabilities are translated at current rates with the exception of inventories, property and equipment and prepaid expenses which are translated at historical rates. Net translation gains and losses, which are not material, are included in operations in the period in which they occur.

Inventories. Inventories are stated at the lower of cost (last-in, first-out and first-in, first-out methods) or market, less progress payments received. Costs include direct material and labor costs and applicable manufacturing and engineering overhead. Sales and related costs are recorded as products are delivered and as services are performed, including products and services under long-term contracts. Costs of products delivered and services performed under such long-term contracts are removed from inventory and charged to cost of sales at amounts approximating actual cost. Any foreseeable losses are charged to income when determined.

Depreciation and Amortization. Buildings and equipment are depreciated on straight-line and declining balance bases. Estimated useful lives are 5 to 45 years for buildings and 3 to 20 years for machinery and equipment. Leasehold improvements and patents are amortized on a straight-line basis over the life of the lease or patent. Maintenance and repairs are charged against income as incurred and betterments and major renewals are capitalized. Cost and accumulated depreciation of property sold, retired or fully depreciated are removed from the accounts, and any resultant gain or loss is included in income.

Cost in Excess of Net Assets of Purchased Businesses. Except for an immaterial amount being amortized, cost in excess of net assets of purchased businesses relates to businesses purchased prior to October 31, 1970 and is not being amortized.

Research and Development. Company funded research and development costs are expensed as incurred. Costs related to customer funded research and development contracts are charged to income as sales are recorded.

Pension Expense. Pension expense is accrued at amounts equal to normal cost plus a portion of prior service costs. The Company contributes accrued pension expense on a current basis.

Income Taxes. Provision for income taxes includes state, Federal and foreign income taxes. Deferred income taxes are provided for timing differences in the recognition of income and expenses, income of the domestic international sales corporation not currently taxed, and undistributed earnings of subsidiaries, except for a portion of the earnings arising from life insurance operations. Investment tax credits are amortized over the estimated lives of the related assets. Certain unconsolidated subsidiaries are included in the Company's consolidated income tax returns; accordingly, accrued and deferred income taxes include amounts representing income tax liabilities resulting from the operations of these subsidiaries.

Other Investments. Investments held by Teledyne's unconsolidated subsidiaries are accounted for by the equity method in the Company's consolidated financial statements when the aggregate voting percentage has exceeded 20 percent for one full quarter. The most recent publicly available financial statements of each investee company are used in determining Teledyne's voting percentage and share of earnings or losses.

(2) Net Income Per Share. Net income per share is based on the weighted average number of shares of common stock and common stock equivalents outstanding during each year, including dilutive options and warrants. Each common stock equivalent has been considered outstanding from the beginning of each year. The average shares of common stock and common stock equivalents used for the calculation of net income per share for the years ended December 31, 1978 and 1977 were 12,965,787 and 13,033,130, respectively.

(3) Inventories. At December 31, 1978 and 1977, the Company's inventories were as follows:

	1978	*1977*
Last-in, first-out method	**$202,447,000**	$188,689,000
First-in, first-out method	**40,432,000**	38,118,000
	242,879,000	226,807,000
Less progress billings	**75,193,000**	65,640,000
	$167,686,000	$161,167,000

Inventories related to long-term contracts were $61,051,000 and $60,320,000 at December 31, 1978 and 1977, respectively. Progress payments related to long-term contracts were $58,547,000 and $58,656,000 at December 31, 1978 and 1977, respectively.

Notes to Consolidated Financial Statements

Inventories stated on a last-in, first-out basis were $139,228,000 and $116,271,000 less than their first-in, first-out values at December 31, 1978 and 1977, respectively. During 1978 and 1977, inventory usage resulted in liquidations of last-in, first-out inventory quantities. These inventories were carried at the lower costs prevailing in prior years as compared with the cost of current purchases. The effect of these last-in, first-out inventory liquidations was to increase net income by approximately $1,530,000, or $0.12 per share, in 1978, and by approximately $3,364,000, or $0.26 per share, in 1977.

(4) Long-Term Debt. At December 31, 1978, the Company's long-term debt was as follows:

10% Subordinated Debentures, due 2004, Series A, $5,452,000 payable annually commencing in 1994 (net of unamortized discount of $28,469,000)	$ 78,090,000
7½% Term Notes, due 1982, $15,000,000 payable annually	75,000,000
7% Subordinated Debentures, due 1999, $1,871,000 payable annually commencing in 1989	35,900,000
7⅞% Sinking Fund Debentures, due 1994, $1,400,000 payable annually	21,610,000
8¾% Promissory Note, due 1983	20,000,000
7% Promissory Notes, due 1989, $1,500,000 payable annually	16,750,000
6½% Sinking Fund Debentures, due 1992, $1,350,000 payable annually	16,647,000
6½% Subordinated Debentures, due 1983, $7,240,000 payable annually	6,490,000
Other (including $9,549,000 secured by property and equipment), due in various installments to 1991	12,447,000
	282,934,000
Less current portion	21,239,000
	$261,695,000

Long-term debt is payable $21,239,000 in 1979, $20,167,000 in 1980, $19,607,000 in 1981, $34,906,000 in 1982 and $31,028,000 in 1983, after reduction for long-term debt repurchased to meet sinking fund requirements. Interest expense was $28,764,000 in 1978 and $29,954,000 in 1977, of which $12,921,000 in 1978 and $12,964,000 in 1977 was allocated to unconsolidated subsidiaries. Discount amortization of $1,217,000 in 1978 and $1,294,000 in 1977 is included in interest expense.

In order to meet current and future sinking fund requirements, the Company repurchased $9,628,000 and $4,726,000 face amount of its long-term debt in 1978 and 1977, respectively. In addition, in 1978, the Company redeemed its 7¼% bonds, payable in German Marks. The resulting losses were included in the results of operations in selling and administrative expenses. These transactions resulted in a decrease in net income of $409,000, or $0.03 per share, in 1978 and $500,000, or $0.04 per share, in 1977.

Under various borrowing agreements, the Company has agreed to maintain minimum amounts of working capital and net worth, and has agreed to certain restrictions with respect to borrowing, sale of assets, purchase of capital stock and payment of dividends. At December 31, 1978, these agreements were complied with, and retained earnings of $470,191,000 were not restricted by these agreements as to payment of dividends.

(5) Capital Stock. At December 31, 1978 and 1977, the Company's capital stock consisted of the following shares:

	Authorized	*1978*	*1977*
Cumulative convertible preferred stock,			
$1 par value—$6 series	15,000,000		
Issued		—	515,774
Outstanding		—	289,862
Common stock, $1 par value	60,000,000		
Issued		32,339,685	32,339,685
Outstanding		12,682,235	11,813,617

At December 31, 1978 and 1977, the Company's treasury stock was as follows:

	1978		*1977*	
	Shares	*Cost*	*Shares*	*Cost*
Cumulative convertible preferred stock—$6 series	—	$ —	225,912	$ 21,880,000
Common stock	19,657,450	466,643,000	20,526,068	435,715,000
		$466,643,000		$457,595,000

In March, 1978, the Company called for redemption its $6 series preferred stock. The preferred stock was convertible into common stock at the rate of 1.34 shares of common stock for each share of preferred stock until April 24, 1978. On April 26, 1978, 56,237 shares of preferred stock, representing the shares which had not been converted, were redeemed at a price of $100 per share, plus accrued dividends.

Options to purchase 583 shares of common stock were outstanding at December 31, 1977. These options were exercised during 1978 at a price of $17 per share. The plan under which these options were granted terminated on November 28, 1978. Common stock held in treasury was issued upon the exercise of options during 1978 and 1977.

The 1977 financial statements and related notes, except for shareholders' equity, have been restated to reflect a 10 percent common stock dividend paid in June, 1978.

(6) Commitments and Contingencies. Five lawsuits brought against the Company in the United States district courts in California, Michigan and Texas, alleging that the Company violated Federal securities laws and state laws in connection with certain repurchases or redemptions of its stock have been dismissed. Appeals in three of the actions have been dismissed or waived. The other two actions are on appeal to the United States Court of Appeals for the Ninth Circuit. One of the actions on appeal seeks an unspecified amount of money damages, the other seeks money damages aggregating more than $8,600,000, and punitive damages of $5,000,000. Another action alleging claims relating to certain repurchases of stock has been filed in the Chancery Court of Delaware and seeks compensatory and punitive damages in an indeterminate amount and alternatively, rescission. The Company believes that the allegations made in these complaints are not meritorious and that the Company has in all instances adequate legal defenses.

The Company has guaranteed the repayment of principal and interest of certain short-term notes payable of UIC Investments, Inc., a subsidiary of the Company's life and casualty insurance subsidiaries. The amount of notes payable outstanding at December 31, 1978 covered by these guarantees was $140,000,000.

(7) Other Costs and Expenses. Total pension expense was $35,623,000 and $33,153,000 in 1978 and 1977, respectively. As of December 31, 1978, the actuarially computed value of vested benefits exceeded the total of the pension fund assets and balance sheet accruals by approximately $68,000,000. The actuarially computed value of prior service costs exceeded such assets and accruals by approximately $85,000,000.

Company funded research and development costs of $30,922,000 and $28,900,000 were charged to costs and expenses in 1978 and 1977, respectively.

(8) Income Taxes. The provision for income taxes for the years ended December 31, 1978 and 1977 were as follows:

	1978	*1977*
Federal	**$153,800,000**	$133,600,000
State	**21,000,000**	20,000,000
Foreign	**6,800,000**	6,200,000
	$181,600,000	$159,800,000

Such provision consisted of the following:

	1978	*1977*
Current	**$168,100,000**	$154,500,000
Deferred	**16,400,000**	7,200,000
Investment credits	**(2,900,000)**	(1,900,000)
	$181,600,000	$159,800,000

Deferred taxes arise principally as a result of the income of the domestic international sales corporation and deferred investment tax credits. The effective tax rate differs from the statutory U.S. Federal income tax rate of 48 percent principally due to state and local income taxes.

(9) Investments in Unconsolidated Subsidiaries. Equity in net income of unconsolidated subsidiaries, after allocated interest expense and income tax items, for the years ended December 31, 1978 and 1977, was as follows:

	1978	*1977*
Equity in net income of:		
Life insurance companies	**$31,525,000**	$23,739,000
Casualty insurance companies	**46,163,000**	8,974,000
	77,688,000	32,713,000
Allocated interest expense	**(12,921,000)**	(12,964,000)
Income tax credits	**6,511,000**	28,842,000
Credit (provision) for deferred taxes on equity in net income (loss) of investments (Note 14)	**1,275,000**	(5,645,000)
	$72,553,000	$42,946,000

The Company's investment in life insurance companies consists primarily of the 95.3 percent ownership of Unicoa Corporation (Note 10). The Company's investment in casualty insurance companies consists primarily of the investment in domestic casualty insurance companies (Note 11), principally Argonaut Insurance Company and Trinity Universal Insurance Company; these subsidiaries are wholly-owned as to voting securities. Included in the equity in net income of the life and casualty insurance companies are amounts representing the incremental effect of accounting for certain investments by the equity method (Note 14).

The income tax credits consist of amounts ($6,590,000 in 1978 and $6,612,000 in 1977) related to the allocated interest expense and amounts ($560,000 in 1978 and $24,253,000 in 1977) related to the net tax losses of unconsolidated subsidiaries which are recoverable in Teledyne's consolidated tax return but which are not available to the unconsolidated subsidiaries on a separate return basis, reduced by a provision ($639,000 in 1978 and $2,023,000 in 1977) for taxes which will become due upon distribution of the earnings of certain unconsolidated subsidiaries. The effective tax rate used in computing the income tax credits related to losses of unconsolidated subsidiaries differs from the statutory U.S. Federal income tax rate of 48 percent principally because of tax exempt investment income.

Interest expense was allocated to unconsolidated subsidiaries based on the ratio of the Company's average investment in unconsolidated subsidiaries to average total capital.

The Company's equity in the net assets of its unconsolidated subsidiaries, including advances, was $320,486,000 in 1978 and $217,258,000 in 1977, including its equity of $232,574,000 and $138,036,000, respectively, in their retained earnings. In consolidation, a portion of the difference between the Company's investments in purchased subsidiaries and the book value of their assets has been allocated to bonds and stocks and amortized over the applicable maturity of the bonds or charged or credited to income upon their disposition. The Company's investment exceeded its equity in net assets by $196,682,000 in 1978 and $196,798,000 in 1977. Such excess is in addition to the excess shown in the consolidated balance sheets and is not being amortized since, in the opinion of management, there has been no diminution in its value. The Company's equity in net income of its unconsolidated subsidiaries includes losses on sales of investments of $2,042,000 in 1978 and $1,402,000 in 1977.

The Company's unconsolidated subsidiaries carry marketable equity securities, including those accounted for by the equity method in the consolidated financial statements of Teledyne, at the lower of aggregate cost or market. The Company's equity in the gross unrealized gains and the gross unrealized losses, which are not included in the determination of the results of operations, was $44,584,000 and $31,540,000, respectively, at December 31, 1978, after adjusting for the effect of the use of the equity method of accounting for certain investments. The reduction to the lower of cost or market is reflected in the consolidated financial statements as a reduction in the investments in unconsolidated subsidiaries and in shareholders' equity. Changes in unrealized depreciation have no effect on net income.

Notes to Consolidated Financial Statements

(10) Unicoa Corporation and Subsidiaries. The following condensed statements summarize the consolidated financial position and operating results of Unicoa Corporation and subsidiaries.

Consolidated Balance Sheets

	December 31,	
	1978	*1977*
Assets:		
Investments:		
Bonds and notes, at amortized cost (market: 1978—$366,752,000; 1977—$305,782,000)	$379,309,000	$306,519,000
Stocks, principally at lower of aggregate cost or market (market: 1978—$263,672,000; 1977—$238,545,000)	245,083,000	233,092,000
Mortgage loans on real estate, less reserve of $7,640,000 in 1978 and $6,990,000 in 1977	92,185,000	109,413,000
Real estate, at cost less accumulated depreciation	41,996,000	41,698,000
Loans to policyholders	17,277,000	16,791,000
Invested cash	249,000	136,000
Total investments	776,099,000	707,649,000
Cash	4,088,000	3,330,000
Uncollected premiums	28,768,000	25,507,000
Deferred policy acquisition costs	114,917,000	115,032,000
Cost in excess of net assets of purchased businesses	25,336,000	25,796,000
Other assets	19,534,000	17,407,000
	$968,742,000	$894,721,000
Liabilities:		
Policy reserves and liabilities	$646,856,000	$631,192,000
Notes payable to banks	24,800,000	22,200,000
Long-term debt	24,410,000	24,966,000
Other liabilities	77,004,000	64,651,000
Shareholders' equity	195,672,000	151,712,000
	$968,742,000	$894,721,000

Consolidated Statements of Income

	Year Ended December 31,	
	1978	*1977*
Premiums and Other Revenue:		
Premiums and other insurance income	$280,050,000	$269,076,000
Net investment income	40,666,000	33,419,000
Other income	2,515,000	3,701,000
	323,231,000	306,196,000
Expenses:		
Benefits paid or provided	128,222,000	148,213,000
Insurance expenses	140,899,000	134,361,000
Provision for income taxes	11,159,000	3,575,000
	280,280,000	286,149,000
	42,951,000	20,047,000
Gain (Loss) on Sale of Investments (excludes unrealized appreciation on marketable equity securities of $14,073,000 in 1978 and unrealized depreciation of $12,587,000 in 1977)	213,000	(2,132,000)
Net Income	$ 43,164,000	$ 17,915,000

Notes to Consolidated Financial Statements

The above statements have been prepared on the basis of generally accepted accounting principles which differ from statutory insurance accounting practices. Life insurance premiums are recognized as revenue when they become due, and revenues, benefits and expenses on accident and health insurance are recognized over the period to which the premiums relate. Deferred taxes are provided for timing differences in the recognition of income and expense.

Marketable equity securities, including those accounted for by the equity method in the consolidated financial statements of Teledyne, are carried at the lower of aggregate cost or market. Any valuation allowance necessary to reduce these securities from cost to market, if lower in the aggregate, is reflected in the consolidated financial statements as a reduction in shareholders' equity; changes thereto have no effect on net income. The net unrealized appreciation was $19,214,000 at December 31, 1978 and $5,141,000 at December 31, 1977. Shareholders' equity was reduced by $796,000 at December 31, 1977, representing the equity in the unrealized depreciation on marketable equity securities held by UIC Investments, Inc., a 20 percent owned unconsolidated subsidiary.

A portion of life insurance income is not subject to Federal income tax until such amount exceeds certain limitations or is distributed to shareholders as dividends. At December 31, 1978, up to $61,000,000 (at current tax rates) would be required for possible Federal income taxes which might become due, in whole or in part, in future years if any portion of $127,000,000 of the gains from operations since January 1, 1959 (which includes $13,000,000 from 1978 and $3,000,000 from 1977) becomes includable in taxable income as a result of such limitations, including distributions in excess of $40,000,000 as dividends.

(11) Domestic Casualty Insurance Subsidiaries. The following condensed statements summarize the combined financial position and operating results of the Company's domestic casualty insurance subsidiaries.

Combined Balance Sheets

	December 31, 1978	December 31, 1977
Assets:		
Investments:		
Bonds and notes, at amortized cost (market: 1978—$496,432,000; 1977—$502,201,000)	$ 516,464,000	$ 496,299,000
Stocks, principally at lower of aggregate cost or market (market: 1978—$460,313,000; 1977—$322,188,000)	450,896,000	320,152,000
Invested cash	4,690,000	60,275,000
Total investments	972,050,000	876,726,000
Cash	18,991,000	21,187,000
Agents' balances and uncollected premiums	47,549,000	45,885,000
Other receivables	38,800,000	26,305,000
Deferred policy acquisition costs	16,324,000	13,118,000
Property and equipment, at cost less accumulated depreciation	3,902,000	4,152,000
Cost in excess of net assets of purchased businesses	4,783,000	4,783,000
	$1,102,399,000	$ 992,156,000
Liabilities:		
Loss and claim reserves	$ 646,377,000	$ 622,287,000
Accrued loss adjustment expenses	105,168,000	103,506,000
Unearned premiums	119,632,000	101,571,000
Other liabilities	57,295,000	49,270,000
Shareholders' equity	173,927,000	115,522,000
	$1,102,399,000	$ 992,156,000

Notes to Consolidated Financial Statements

Combined Statements of Operations

	Year Ended December 31, 1978	1977
Premiums and Other Revenues:		
Net premiums earned	$ 367,889,000	$ 365,927,000
Net investment income	48,555,000	40,768,000
	416,444,000	406,695,000
Expenses:		
Losses and loss adjustment expenses	253,891,000	295,491,000
Underwriting expenses	96,314,000	105,306,000
Provision for income taxes	15,818,000	7,256,000
	366,023,000	408,053,000
	50,421,000	(1,358,000)
Gain (Loss) on Sale of Investments (excludes unrealized appreciation on marketable equity securities of $10,054,000 in 1978 and unrealized depreciation of $16,620,000 in 1977)	(1,116,000)	630,000
	49,305,000	(728,000)
Income Tax Reduction	7,369,000	—
Net Income (Loss)	$ 56,674,000	$ (728,000)

The above statements have been prepared on the basis of generally accepted accounting principles which differ from statutory insurance accounting practices. Premium income, policy acquisition costs and policyholder dividends are recognized ratably over the period to which the premiums relate. Losses and loss adjustment expenses are provided at the estimated amounts necessary to settle incurred claims. Deferred taxes are provided for timing differences in the recognition of income and expenses to the extent such deferred taxes are determined to be due.

Marketable equity securities, including those accounted for by the equity method in the consolidated financial statements of Teledyne, are carried at the lower of aggregate cost or market. Any valuation allowance necessary to reduce these securities from cost to market, if lower in the aggregate, is reflected in the combined financial statements as a reduction in shareholders' equity; changes thereto have no effect on the results of operations. The net unrealized appreciation on marketable equity securities was $8,806,000 at December 31, 1978,and the net unrealized depreciation was $1,248,000 at December 31, 1977.

Investments in stocks includes $31,482,000 in 1978 and $34,177,000 in 1977 of investments in the common stock of unconsolidated subsidiaries accounted for by the equity method. Shareholders' equity was reduced by $3,183,000 at December 31, 1977, representing the equity in the unrealized depreciation on marketable equity securities held by UIC Investments, Inc., an 80 percent owned subsidiary accounted for by the equity method. Shareholders' equity includes $20,000,000 of certificates of contribution issued to Teledyne in exchange for $20,000,000 of Teledyne's 10% subordinated debentures (included in bonds and notes in the above combined balance sheets).

Taxable income of the domestic casualty insurance subsidiaries is included in the consolidated income tax return of Teledyne. Certain of the subsidiaries reimburse Teledyne for their portion of Teledyne's consolidated Federal income tax liability. The Federal income tax provision reflected in the combined financial statements approximates the provision which would be made on a separate company basis. Certain of the domestic casualty insurance subsidiaries are not being required to reimburse Teledyne for their 1978 Federal income tax provision. The income tax reduction of $7,369,000 in the combined statement of operations for 1978 represents the amount of those taxes which will not be reimbursed.

Notes to Consolidated Financial Statements

(12) UIC Investments, Inc. The following condensed statements summarize the financial position and operating results of UIC Investments, Inc. UIC Investments, Inc. is 80 percent owned by Trinity Universal Insurance Company and 20 percent owned by a wholly-owned subsidiary of Unicoa Corporation.

Balance Sheets

	December 31,	
	1978	*1977*
Assets:		
Investments in common stock, at the lower of aggregate cost or market (1978 Market – $204,062,000; 1977 Cost – $170,548,000)	$194,177,000	$166,569,000
Short-term investments, at cost which approximates market	4,000,000	2,700,000
Cash	197,000	92,000
Accrued investment income	481,000	356,000
	$198,855,000	$169,717,000
Liabilities:		
Notes payable to banks	$140,000,000	$120,000,000
Accounts payable	12,000	2,971,000
Accrued interest	1,584,000	993,000
Notes payable to affiliates	70,910,000	51,035,000
Shareholders' equity (deficit)	(13,651,000)	(5,282,000)
	$198,855,000	$169,717,000

Statements of Operations

	Year Ended December 31,	
	1978	*1977*
Investment income	$ 5,624,000	$ 3,762,000
Interest expense	17,417,000	9,517,000
Other expenses	98,000	122,000
Gain (Loss) on sale of investments	(457,000)	185,000
Net Loss	$(12,348,000)	$ (5,692,000)

Short-term investments are carried at cost, which approximates market. Investments in common stocks, including those accounted for by the equity method in the consolidated financial statements of Teledyne, are carried at the lower of aggregate cost or market. Any valuation allowance necessary to reduce common stocks from cost to market, if lower in the aggregate, is reflected in the financial statements as a reduction in shareholders' equity; changes thereto have no effect on the results of operations. The net unrealized appreciation on common stocks was $9,885,000 at December 31, 1978, and the net unrealized depreciation was $3,979,000 at December 31, 1977.

Taxable income of UIC Investments, Inc. is included in the consolidated tax returns of Teledyne. No income tax credits have been included in the financial statements of UIC Investments, Inc. since the losses for tax purposes could not be used on a separate return basis.

Notes to Consolidated Financial Statements

(13) Fireside Securities Corporation and Subsidiaries. The following condensed statements summarize the consolidated financial position and operating results of Fireside Securities Corporation and subsidiaries. Fireside Securities Corporation is a wholly-owned subsidiary of Argonaut Insurance Company.

Consolidated Balance Sheets

	December 31,	
	1978	*1977*
Assets:		
Cash	$ 2,798,000	$ 2,744,000
Short-term investments	4,983,000	—
Bonds, at amortized cost (market: 1978—$338,000; 1977—$8,748,000)	341,000	8,775,000
Loans receivable	148,718,000	133,117,000
Premises and equipment, at cost less accumulated depreciation	2,144,000	1,533,000
Other assets	872,000	839,000
	$159,856,000	$147,008,000
Liabilities:		
Investment certificates	$135,332,000	$124,464,000
Other liabilities	3,073,000	3,015,000
Shareholders' equity	21,451,000	19,529,000
	$159,856,000	$147,008,000

Consolidated Statements of Income

	Year Ended December 31,	
	1978	*1977*
Revenues:		
Interest on loans	$ 26,020,000	$ 23,461,000
Other income	4,679,000	3,914,000
	30,699,000	27,375,000
Expenses:		
Interest on investment certificates	8,823,000	8,040,000
General and administrative	15,349,000	13,262,000
Loss on sale of investments	322,000	25,000
Provision for losses on loans receivable	2,180,000	2,810,000
Provision for income taxes	2,103,000	1,442,000
	28,777,000	25,579,000
Net Income	$ 1,922,000	$ 1,796,000

The consolidated financial statements of Fireside Securities Corporation include the accounts of all its subsidiaries. Loans receivable are stated net of unearned discount. Deferred income taxes are provided for timing differences in the recognition of income and expenses.

Taxable income of Fireside Securities Corporation and its subsidiaries is included in the consolidated income tax return of Teledyne.

(14) Other Equity Investments. The Company's consolidated financial statements reflect the effects of the use of the equity method of accounting for certain investments owned by the Company's unconsolidated subsidiaries. Investments accounted for by the equity method, and approximate voting percentages based on the most recent publicly available data, were: Brockway Glass Company, Inc. (29 percent), Curtiss-Wright Corporation (31 percent), Litton Industries, Inc. (25 percent) and Reichhold Chemicals, Inc. (21 percent).

Teledyne's equity in the net income (loss) of these companies, after income taxes, was ($12,151,000) in 1978 and $14,438,000 in 1977; these amounts include dividends recorded by Teledyne's unconsolidated subsidiaries. Income taxes (credits) have been provided at appropriate rates for that portion of the equity in net income received as dividends and at capital gains rates on the balance. The incremental effect of the use of the equity method was to decrease equity in net income of unconsolidated subsidiaries and net income by $16,931,000, or $1.31 per share, in 1978 and to increase equity in net income of unconsolidated subsidiaries and net income by $11,137,000, or $0.85 per share, in 1977.

Teledyne's equity in the aggregate carrying value of these investments was $250,686,000 and $245,664,000 at December 31, 1978 and 1977, respectively. The aggregate market value of these investments, based on quoted market prices, was $273,214,000 and $225,440,000 at December 31, 1978 and 1977, respectively. The equity in the net assets of these companies exceeded the carrying value of the investments by approximately $30,000,000 in 1978. Of this amount, approximately $9,000,000 has been considered to be related to cost in excess of net assets of purchased businesses reported in the financial statements of the investee companies; the remaining balance is not being amortized.

The consolidated financial statements for 1977 have been restated to reflect the use of equity accounting for the investment in Reichhold Chemicals, Inc. The effect was to increase equity in net income of unconsolidated subsidiaries and net income by $701,000, or $0.05 per share.

(15) Business Segments. The Company's major business segments include industrial products, specialty metals, aviation and electronic products and consumer products. Internal combustion engines are the major product of the industrial segment, including the manufacture of air and water cooled, gasoline and diesel fueled engines. Other products in this segment include machine tools, dies and consumable tooling. Specialty metal products include zirconium, high speed and alloy steels, tungsten and molybdenum. Other operations in this segment include processing, casting, roll forming and forging metals into a variety of finished forms. Aviation and electronic products include aircraft engines, remotely piloted vehicles, drone systems, spacecraft and avionics. This segment also includes semiconductors, relays, aircraft monitoring and control systems, military electronic equipment and other related products and systems. The consumer segment includes oral hygiene products, shower massages, high fidelity speakers and other products and services.

The Company's unconsolidated subsidiaries are primarily insurance companies. One group writes life and accident and health insurance. Another group writes a broad line of casualty insurance including workers' compensation, liability, automobile, homeowners and fire insurance. Business is done primarily in the United States.

Sales between business segments, which were not material, generally were priced at prevailing market prices. The Company's sales to the U.S. Government were $562,021,000 in 1978 and $519,317,000 in 1977, including direct sales as prime contractor and indirect sales as subcontractor; the industrial and aviation and electronics segments made most of these sales. Sales by operations in the United States to customers in other countries were $189,751,000 in 1978 and $193,963,000 in 1977.

Information on the Company's business segments for the years ended December 31, 1978 and 1977 is as follows:

	1978	*1977*
Revenues:		
Industrial	$ 914,615,000	$ 814,450,000
Specialty metals	698,028,000	600,828,000
Aviation and electronics	539,102,000	491,096,000
Consumer	289,884,000	303,357,000
Total Consolidated Sales	2,441,629,000	2,209,731,000
Insurance and finance revenues	779,127,000	750,706,000
Total Revenues	$3,220,756,000	$2,960,437,000

Notes to Consolidated Financial Statements

	1978	1977
Operating Profit:		
Industrial	$ 150,347,000	$ 134,399,000
Specialty metals	115,685,000	81,872,000
Aviation and electronics	72,652,000	67,994,000
Consumer	32,062,000	49,538,000
Total Operating Profit	370,746,000	333,803,000
Corporate expenses	14,109,000	16,812,000
Interest expense	15,843,000	16,990,000
Interest and dividend income	(16,756,000)	(11,636,000)
Consolidated Income Before Income Taxes	$ 357,550,000	$ 311,637,000
Equity in Net Income of Unconsolidated Subsidiaries:		
Equity in net income of:		
Life insurance companies	$ 31,525,000	$ 23,739,000
Casualty insurance companies	46,163,000	8,974,000
	77,688,000	32,713,000
Allocated interest expense	(12,921,000)	(12,964,000)
Income tax credits	6,511,000	28,842,000
Credit (provision) for deferred taxes on equity in net income (loss) of investments	1,275,000	(5,645,000)
	$ 72,553,000	$ 42,946,000
Depreciation and Amortization Expense:		
Industrial	$ 27,618,000	$ 20,300,000
Specialty metals	15,251,000	14,322,000
Aviation and electronics	9,887,000	9,179,000
Consumer	2,669,000	2,796,000
General corporate	1,811,000	1,642,000
Total Depreciation and Amortization Expense	$ 57,236,000	$ 48,239,000
Identifiable Assets:		
Industrial	$ 319,618,000	$ 265,601,000
Specialty metals	225,560,000	209,342,000
Aviation and electronics	145,064,000	125,042,000
Consumer	80,165,000	99,874,000
	770,407,000	699,859,000
General corporate assets	268,353,000	288,142,000
Investments in unconsolidated subsidiaries:		
Life insurance companies	290,410,000	252,848,000
Casualty insurance companies	227,820,000	182,908,000
Total Assets	$1,556,990,000	$1,423,757,000
Capital Expenditures:		
Industrial	$ 65,393,000	$ 28,410,000
Specialty metals	17,212,000	16,927,000
Aviation and electronics	14,226,000	8,847,000
Consumer	1,794,000	4,085,000
General corporate	3,394,000	2,135,000
Total Capital Expenditures	$ 102,019,000	$ 60,404,000

Notes to Consolidated Financial Statements

(16) Selected Quarterly Financial Data (Unaudited).

	Quarter Ended			
	March 31	*June 30*	*September 30*	*December 31*
1978—				
Consolidated Sales	$578,021,000	$621,412,000	$588,487,000	$653,709,000
Consolidated Gross Profit	$144,216,000	$158,296,000	$156,497,000	$176,963,000
Income of Consolidated Companies	$ 34,302,000	$ 41,776,000	$ 43,335,000	$ 56,537,000
Equity in Net Income (Loss) of Unconsolidated Subsidiaries	18,354,000	24,036,000	(1,402,000)	31,565,000
Net Income	$ 52,656,000	$ 65,812,000	$ 41,933,000	$ 88,102,000
Average Shares Outstanding	13,051,110	13,048,209	12,944,216	12,807,501
Net Income Per Share	$4.00	$5.04	$3.24	$6.88
1977—				
Consolidated Sales	$545,859,000	$524,637,000	$550,710,000	$588,525,000
Consolidated Gross Profit	$139,626,000	$132,472,000	$146,665,000	$166,055,000
Income of Consolidated Companies	$ 34,198,000	$ 31,446,000	$ 38,682,000	$ 47,511,000
Equity in Net Income (Loss) of Unconsolidated Subsidiaries	12,347,000	(3,788,000)	17,604,000	16,783,000
Net Income	$ 46,545,000	$ 27,658,000	$ 56,286,000	$ 64,294,000
Average Shares Outstanding	13,031,391	13,043,169	13,026,693	13,031,271
Net Income Per Share	$3.54	$2.09	$4.29	$4.90

During the quarter ended June 30, 1978 the Company restated the previously reported results of operations to reflect the effects of the use of equity accounting for Reichhold Chemicals, Inc. The effect was to increase equity in net income of unconsolidated subsidiaries and net income as follows:

Quarter Ended	*Amount*	*Net Income Per Share*
March 31, 1978	$314,000	$0.02
December 31, 1977	89,000	0.01
September 30, 1977	262,000	0.02
June 30, 1977	126,000	0.01
March 31, 1977	224,000	0.02

During the quarter ended September 30, 1978, a loss was reflected in equity in net income of unconsolidated subsidiaries. This resulted from the use of equity accounting for certain investments held by the subsidiaries, including an investment in Litton Industries, Inc. which reported a loss for its fourth quarter ended July 31, 1978.

During the quarter ended June 30, 1977, the combined operations of the Company's unconsolidated subsidiaries resulted in a loss. This was due primarily to adverse loss development in reinsurance assumed from other underwriters by Argonaut Insurance Company, one of Teledyne's domestic casualty insurance subsidiaries. Among the unconsolidated life insurance subsidiaries, earnings at United Insurance Company of America declined as a result of the provision of additional reserves on accident and health policies.

(17) Supplemental Information on Replacement Cost (Unaudited). The impact of inflation on the costs of goods and services varied among the business segments. The effects of such inflation, and the related effects on selling prices, are generally reflected in the results of operations over a relatively short period of time. The impact of inflation on the replacement cost of productive capacity, however, is usually more long-term in nature. In compliance with the rules of the Securities and Exchange Commission, the Company has calculated certain estimated replacement cost information for inventories, cost of sales, property and equipment and the related depreciation and amortization. This information will be presented in the Annual Report on Form 10-K of Teledyne, Inc. for the year ended December 31, 1978.

Consolidated Summary of Operations

For the Five Years Ended December 31, 1978
(000's omitted except average share and per share amounts)

	1978	1977	1976	1975	1974
Consolidated sales	$2,441,629	$2,209,731	$1,937,556	$1,714,972	$1,699,987
Consolidated gross profit	$ 635,972	$ 584,818	$ 500,387	$ 391,269	$ 328,793
Consolidated interest expense (Note A)	$ 15,843	$ 16,990	$ 18,756	$ 22,254	$ 22,561
Consolidated provision for income taxes (Note B)	$ 181,600	$ 159,800	$ 123,000	$ 85,300	$ 64,200
Income of consolidated companies (Note D)	$ 175,950	$ 151,837	$ 113,255	$ 82,619	$ 62,826
Equity in net income (loss) of unconsolidated subsidiaries, after allocated expenses and income tax items (Notes A, C and D)	72,553	42,946	23,544	19,087	(31,321)
Net income (Note D)	248,503	194,783	136,799	101,706	31,505
Dividend requirements of preferred stock	387	1,739	2,365	3,425	3,662
Net income applicable to common shareholders	$ 248,116	$ 193,044	$ 134,434	$ 98,281	$ 27,843
Average shares outstanding:					
Primary	12,965,787	13,033,130	13,955,477	19,052,119	26,149,673
Fully diluted	13,076,921	13,465,111	14,538,310	19,847,969	26,149,673
Net income per share:					
Primary	$19.13	$14.81	$9.66	$5.22	$1.12
Fully diluted	$19.00	$14.47	$9.42	$5.17	$1.12

The Company has paid stock dividends applicable to the common stock during each of the years presented above; no cash dividends have been paid on the common stock.

Notes to Consolidated Summary of Operations

(000's omitted except for per share amounts)

(A) Interest expense was $28,764 in 1978, $29,954 in 1977, $31,260 in 1976, $34,980 in 1975 and $37,785 in 1974, of which $12,921 in 1978, $12,964 in 1977, $12,504 in 1976, $12,726 in 1975 and $15,224 in 1974 was allocated to unconsolidated subsidiaries based on the ratio of the Company's average investment in unconsolidated subsidiaries to the Company's average total capital. Interest expense on long-term debt approximated total interest expense for all periods presented.

(B) The consolidated provision for income taxes includes the following:

	1978	1977	1976	1975	1974
Federal	$153,800	$133,600	$106,500	$ 71,200	$ 51,300
State	21,000	20,000	13,700	9,400	8,400
Foreign	6,800	6,200	2,800	4,700	4,500
Total	$181,600	$159,800	$123,000	$ 85,300	$ 64,200
Current	$168,100	$154,500	$116,200	$ 76,700	$ 55,100
Deferred	16,400	7,200	8,400	9,500	10,700
Investment credits	(2,900)	(1,900)	(1,600)	(900)	(1,600)
Total	$181,600	$159,800	$123,000	$ 85,300	$ 64,200

(C) The Company's equity in net income (loss) of its unconsolidated subsidiaries includes losses on sales of investments of $2,042 in 1978, $1,402 in 1977, $6,874 in 1976, $9,435 in 1975 and $19,199 in 1974.

(D) In order to meet current and future sinking fund requirements, the Company repurchased some of its long-term debt ($9,628 in 1978, $4,726 in 1977, $18,389 in 1976, $20,142 in 1975 and $59,071 in 1974). In addition, the Company redeemed its 7¼% bonds in 1978 and its 3½% subordinated debentures in 1976. The resulting gains and losses were included in the results of operations. These transactions resulted in an increase (decrease) in net income of $(409) or $(0.03) per share ($(0.03) fully diluted) in 1978, $(500) or $(0.04) per share ($(0.04) fully diluted) in 1977, $(1,181) or $(0.08) per share ($(0.08) fully diluted) in 1976, $3,362 or $0.18 per share ($0.17 fully diluted) in 1975 and $2,555 or $0.10 per share in 1974. In 1974, the Company realized a gain of $12,196 or $0.47 per share, after taxes, on the sale of assets of consolidated companies.

The equity method of accounting is used for certain investments held by the Company's unconsolidated subsidiaries. The incremental effect of the use of this method was to decrease equity in net income of unconsolidated subsidiaries and net income by $16,931 or $1.31 per share ($1.29 fully diluted) in 1978 and increase equity in net income of unconsolidated subsidiaries and net income by $11,137 or $0.85 per share ($0.83 fully diluted) in 1977 and by $1,920 or $0.14 per share ($0.13 fully diluted) in 1976. There was no effect on prior years. The 1977 summary of operations has been restated to reflect the use of this method for an additional investee; the effect was to increase equity in net income of unconsolidated subsidiaries and net income by $701,000 or $0.05 per share ($0.05 fully diluted).

During 1978, 1977, 1976 and 1975, inventory usage resulted in liquidations of last-in, first-out inventory quantities. These inventories were carried at the lower costs prevailing in prior years as compared with the cost of current purchases. The effect of these last-in, first-out inventory liquidations was to increase net income by approximately $1,530 or $0.12 per share ($0.12 fully diluted) in 1978, $3,364 or $0.26 per share ($0.25 fully diluted) in 1977, $4,725 or $0.34 per share ($0.33 fully diluted) in 1976 and $6,150 or $0.32 per share ($0.31 fully diluted) in 1975.

Management's Discussion and Analysis of Summary of Operations

1978 Compared with 1977. Consolidated sales for the year ended December 31, 1978 increased approximately 10 percent over the prior year. The specialty metals, industrial and aviation and electronics segments had sales increases of approximately 16, 12 and 10 percent, respectively, resulting from both increased demand for these products and price increases. The consumer segment experienced a slight sales decline, principally as a result of lower volume. Consolidated gross profit increased approximately 9 percent, in line with the sales increase. A gross profit rate decline in the consumer segment was offset by improvements in other segments.

Interest expense declined slightly in 1978, primarily as a result of the repurchases and redemption of long-term debt discussed in Note D to the Consolidated Summary of Operations; this was partially offset by the issuance of new long-term debt during the year. Payroll taxes increased approximately 20 percent in 1978, the result of higher payroll tax rates. Interest and dividend income increased during 1978, primarily the result of higher yields available on investments. Advertising costs declined by approximately 20 percent in 1978, primarily in the consumer segment, where a higher level of costs had been incurred in 1977 in connection with the introduction of new products. The increase in pretax income resulted in a higher provision for income taxes.

Equity in net income of unconsolidated subsidiaries increased significantly in 1978, despite a substantial reduction due to the use of the equity method of accounting for certain investments owned by these subsidiaries; this equity accounting effect is discussed in Note D to the Consolidated Summary of Operations. Improved results of operations were reported by both the life insurance and the casualty insurance subsidiaries; these improved results were primarily due to improvements in underwriting, and net investment income also increased significantly. Underwriting improvements were especially significant in the accident and health segment of the Company's life insurance subsidiaries.

1977 Compared with 1976. Consolidated sales for the year ended December 31, 1977 increased approximately 14 percent from 1976, due both to price increases and increased demand. All business segments experienced sales increases, with the specialty metals and industrial segments experiencing increases of 18 percent and 16 percent, respectively. The increased gross profit is primarily attributable to the increased sales.

Interest expense declined in 1977, primarily as a result of the repurchases of debt discussed in Note D to the Consolidated Summary of Operations. Payroll taxes increased approximately 14 percent in 1977, a result of higher tax rates and a higher level of employment. Advertising costs increased approximately 11 percent in 1977, primarily in the consumer segment where new products were introduced during the year. The increased pretax income is the major reason for the higher 1977 provision for income taxes.

Equity in net income of unconsolidated subsidiaries increased in 1977. The casualty insurance subsidiaries contributed over one-half of this increase, with some improvements in underwriting and the realization of gains on sales of investments in 1977 compared to losses in 1976. The other major contribution to this increase was the effect of the use of the equity method of accounting for certain investments as discussed in Note D to the Consolidated Summary of Operations.

Revenue By Business Segment

(000's Omitted)

	Year Ended December 31,				
	1978	*1977*	*1976*	*1975*	*1974*
Industrial	$ 914,615	$ 814,450	$ 701,816	$ 613,347	$ 599,604
Specialty Metals	698,028	600,828	508,255	455,003	487,013
Aviation and Electronics	539,102	491,096	453,383	460,255	433,180
Consumer	289,884	303,357	274,102	186,367	180,190
Consolidated Sales	2,441,629	2,209,731	1,937,556	1,714,972	1,699,987
Insurance and Finance	779,127	750,706	703,670	758,003	732,318
Total	$3,220,756	$2,960,437	$2,641,226	$2,472,975	$2,432,305

Net Income By Business Segment

(000's Omitted)

	Year Ended December 31,				
	1978	*1977*	*1976*	*1975*	*1974*
Industrial	$ 71,853	$ 61,494	$ 39,699	$ 36,788	$ 31,731
Specialty Metals	54,473	36,279	28,847	15,046	21,687
Aviation and Electronics	35,009	31,696	25,138	17,709	10,098
Consumer	14,615	22,368	19,571	13,076	(690)
Consolidated	175,950	151,837	113,255	82,619	62,826
Insurance and Finance	72,553	42,946	23,544	19,087	(31,321)
Total	$ 248,503	$ 194,783	$ 136,799	$ 101,706	$ 31,505

Additional 1978 and 1977 information regarding business segments, including operating profit, assets, capital expenditures and depreciation, is presented in Note 15 to the Consolidated Financial Statements.

Industrial Products Teledyne's diverse line of industrial products represents the company's largest single area of activity.

Engines of many sorts—air and water cooled, gasoline and diesel fueled—are major products in this category. Teledyne piston engines range in power from lightweight, portable, air cooled engines of a few horsepower, up to heavy-duty turbocharged diesel engines approaching 2000 horsepower for use in military tanks and heavy construction equipment.

Another category of industrial products includes machine tools, dies and consumable tooling of all types. These range from numerically-controlled pipe and tube bending machines to a great variety of machines designed for the high speed production of precision machine threads by cutting, grinding and roll-forming methods, and a variety of similar equipment for the production of precision roll-formed gears. Presses, cut-off machines and can-making machines are also produced.

Other Teledyne production equipment includes transfer and assembly machines for the automated production of many kinds of products, as well as multi-gun automated resistance welding machines, single station manual resistance welding machines, welding power supplies, arc welding equipment, and consumable supplies such as welding electrodes and tubular and solid welding wire.

Unusual among Teledyne's welding products are the world's largest welding positioners and manipulators with capacities to 227 tons. These immense Teledyne machines are used worldwide by the nuclear industry for welding and cladding nuclear reaction vessels with stainless steel.

Teledyne also produces complete automated bakery production lines and chemical process equipment as well.

Closely related to the machine tool field are Teledyne's optical encoders and digital readouts which may be added to existing milling machines and other machine tools to modernize them, increase operator output and improve the accuracy of the work produced.

Teledyne also makes a variety of analytical instruments for pollution control, mine and industrial safety, petrochemical process control, and for medical and deep sea saturation diving applications.

These include percentage and parts per million oxygen detectors, hydrocarbon detectors, and photometric instruments for measuring oil or phenol in water and dozens of other chemicals in the parts per million or billion range. Other related products include a variety of

instruments for the physical testing of materials, meteorological instruments, equipment and services for the detection, monitoring and analysis of radioactive materials including nuclear dosimeters for monitoring the exposure levels of nuclear industry personnel, high-speed motion picture cameras, and equipment for the film recording of video images.

Control systems based on computer logic are provided to the petrochemical industry for controlling the flow of natural gas and oil through nationwide networks of pipelines. Electrically actuated control valves and large safety relief valves are supplied to this and other industries, as well.

Teledyne also produces a complete line of seismic instrumentation and related computer systems used throughout the world in earthquake monitoring and oil exploration.

In addition, Teledyne carries out seismic surveys on land and under the sea bottom on a contract basis to locate likely oil bearing strata for major oil companies.

Related activities include the fabrication and installation of large offshore oil platforms for the oil industry, as well as drilling and workover services and a variety of maintenance and salvage operations carried out in offshore areas.

The company owns and operates sea-going derrick barges up to 800 ton lifting capacity and numerous submersible, jack-up, and platform-type drilling rigs to carry on this work for the oil industry.

Sophisticated computer designed gas-lift equipment and services are also provided by the company for stimulating and increasing the flow of older or less productive wells.

Related geophysical activities include aerial surveying and mapping services, as well as the production of a broad line of transits and theodolites for surveying use.

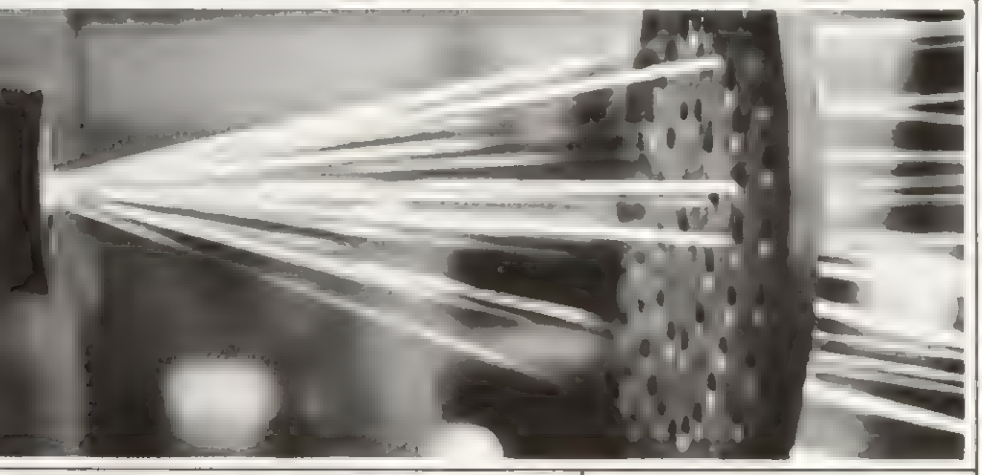
Among Teledyne's remaining miscellaneous industrial activities are the production of solid rubber tires and molded rubber products for the automotive industry.

Uninterruptible power supplies are produced for the computer industry to eliminate computer failures caused by substandard power or momentary power interruptions.

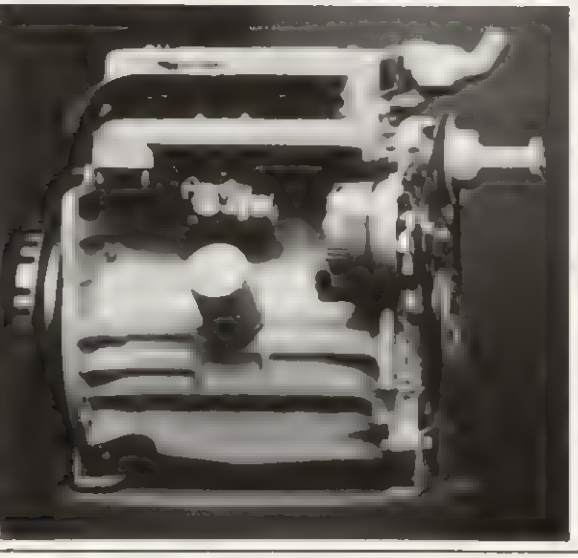
Thermoelectric generators fueled with propane or natural gas are made for use in remote unattended locations where small amounts of electrical power are required, and other Teledyne thermoelectric generators powered by radioisotopic materials provide power for deep space missions such as the Viking probes to Mars. This same Teledyne division also produces high purity electrolytic hydrogen generators that are used in many laboratory and industrial processes.

At the end of this list of industrial activities is the area of waste disposal. Teledyne engineers, produces and

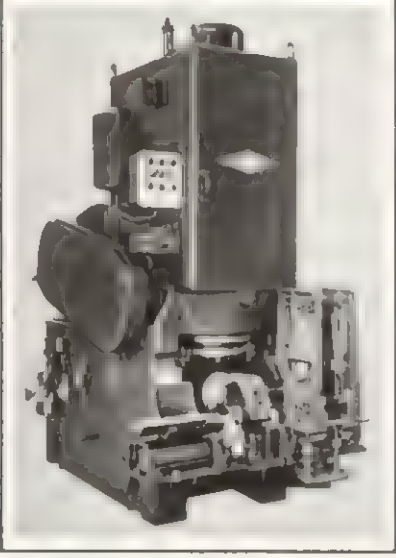
Wire & Cable



Offshore Drilling & Construction



Industrial Engines



Machine Tools

operates large scale solid waste systems for local municipalities, that efficiently recover useful metals and materials from rubbish while producing useful amounts of energy. Teledyne also provides services for the disposal of radioactive waste, as well.

Specialty Metals Teledyne specialty metals and alloys are used in industrial, aerospace and nuclear applications.

Basic to the production of virtually every modern metal product are Teledyne's high speed steels which provide the high temperature hardness required for lathe bits, drills, milling cutters, taps and dies and other cutting tools. Related alloy steels are produced for bearings, gears and special aerospace hardware.

Parallel to high speed steels is Teledyne's line of sintered tungsten carbide products, made by combining carbon, tungsten and various other metals under heat to produce a material that approaches the diamond in hardness, at far lower cost. It is vital for super hard cutters used in the high speed machining and cutting of steel and many other materials.

Among other metals produced by Teledyne are superalloys, engineered to retain their high tensile strength at temperatures approaching 2000° Fahrenheit, for use in jet engine turbine parts which operate under tremendous centrifugal forces at temperatures that would melt ordinary steels.

Teledyne also produces tungsten, a unique metal that is the most heat resistant of all metals and is more than one-and-one-half times as dense as lead. Teledyne mines tungsten ore and produces both pure tungsten powder and tungsten carbide powder as well as finished tungsten mill products. It is used in diverse applications ranging from light bulb filaments and electrical contacts to radiation shielding and aircraft counterweights.

Molybdenum, a sister metal to tungsten produced by Teledyne, also has a very high melting point. It is an important alloying element for steels and is used for plasma arc spraying of piston rings and for electrodes in glass melting furnaces.

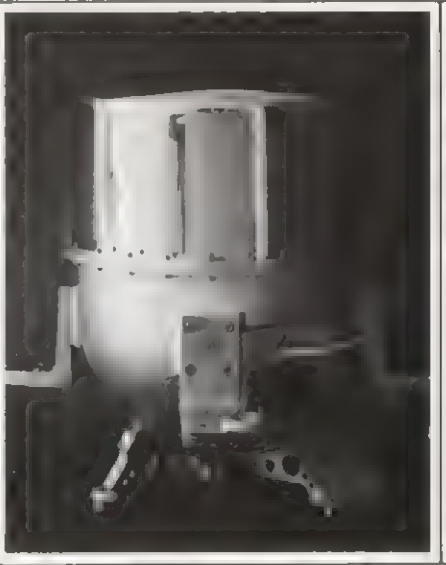
In the area of more exotic metals, Teledyne produces columbium, also known as niobium, which retains its ductility at both high temperatures and low cryogenic temperatures. It is used for rocket nozzles, and, combined with other metals, is a prime ingredient of superconducting alloys.

At the opposite end of the scale from tungsten is titanium, valued for its lightweight strength. Teledyne produces titanium in ingot, billet and coil for a variety of aerospace uses.

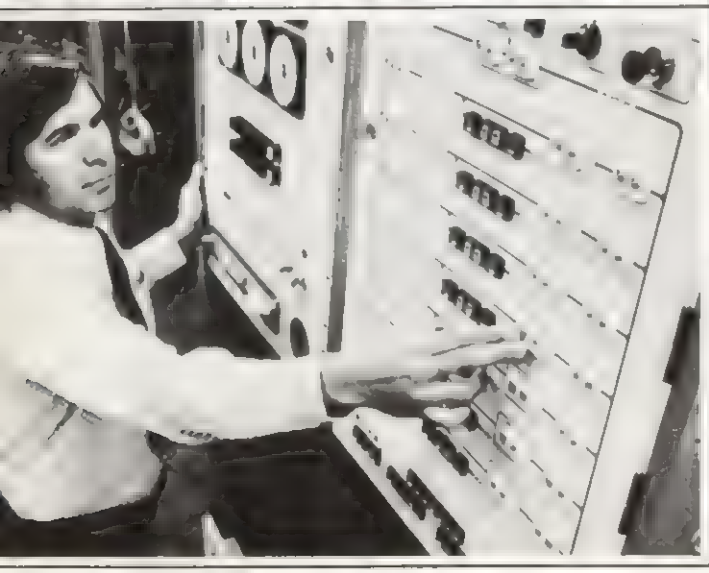
Teledyne is the leading U.S. producer of zirconium, a highly corrosion resistant metal that is transparent to neutrons. It is used for fuel tubes and structural parts in

High Speed Camera Systems

Seismometers

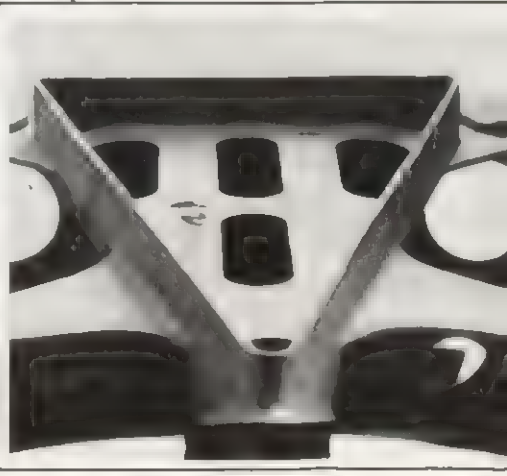


Hardfacing Welding Alloys



Uninterruptible Power Systems

Industrial Tires



Investment Castings

nuclear reactors, in the form of foil in flash cubes, and for corrosion-resistant chemical industry equipment. Hafnium, derived as a by-product of zirconium, is used for control rods in nuclear reactors.

Teledyne also processes metals into a variety of finished forms. Over 60 different metals and alloys, for example, are rolled into ultrathin sheet and foil that is used for applications ranging from watch springs and flash bulbs to aerospace honeycomb materials.

Teledyne also casts a variety of metals into forms ranging from 90-ton steel mill rolls to lightweight aluminum and magnesium aircraft parts. High pressure pipe for the chemical industry is made by centrifugal casting, and a variety of housings and parts are made for business machines, tools and automobiles by die casting methods. Cold-finished bar and shafting and cold-drawn seamless and welded tubing are also produced.

Other Teledyne companies are involved in roll-forming metals, forging heavy parts for construction and earth moving machinery and precision investment casting of difficult to produce parts.

Aviation and Electronics Products in the closely related fields of aviation and electronics range from the microscopic world of semiconductor devices to full-scale air frames and complete aircraft.

At the small end of the scale are Teledyne's basic semiconductor building blocks. These include transistors, diodes and integrated circuits. A step up from these tiny components are hybrid microcircuits the size of postage stamps, including a complete microcomputer that contains 72,000 active elements on a ceramic base the size of a soda cracker. In the two Viking missions to Mars, over twenty-seven hundred Teledyne hybrid microcircuits of various types were used.

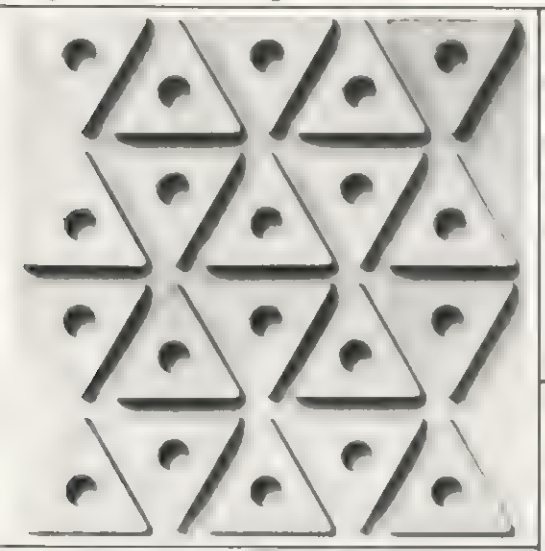
On a still larger scale are Teledyne's high power traveling wave tubes, used to simultaneously transmit thousands of telephone conversations—or a dozen television channels—around the world via satellite networks.

Other components include operational amplifiers, digital-analog converters, miniature relays, radar augmentors, low power microwave tubes, flexible printed-circuit interconnections, high reliability wire and cable, switches, terminals, and a line of aircraft batteries.

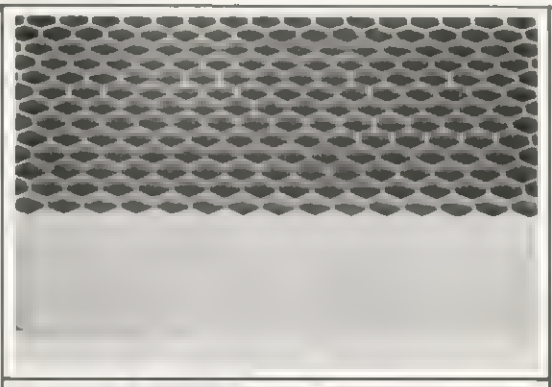
At the systems level, Teledyne produces equipment for telemetering data from remote sources, for electronic countermeasures, and for information processing, as well as the AIDS aircraft integrated data systems used by dozens of major airlines to record in-flight performance and maintenance data on their jumbo jets.

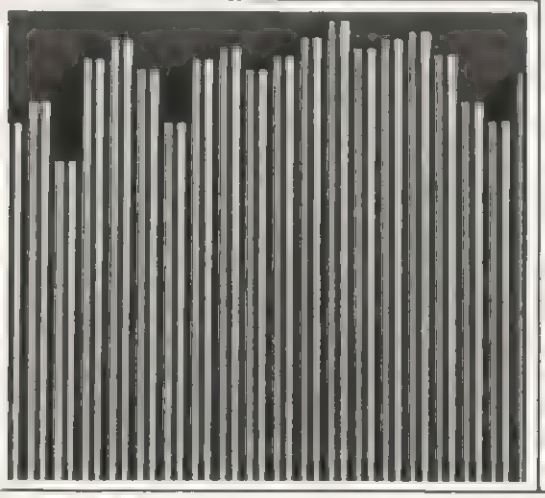
Computing and inertial systems are also produced for the control and guidance of aircraft and space vehicles. Teledyne on-board computers have successfully controlled the launching of dozens of spacecraft, including both Viking missions to Mars.

Tungsten Carbide Cutting Inserts

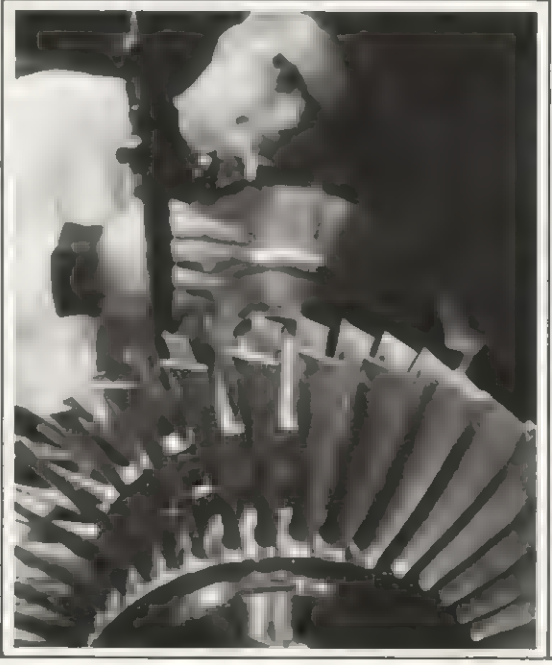


Thin Metals

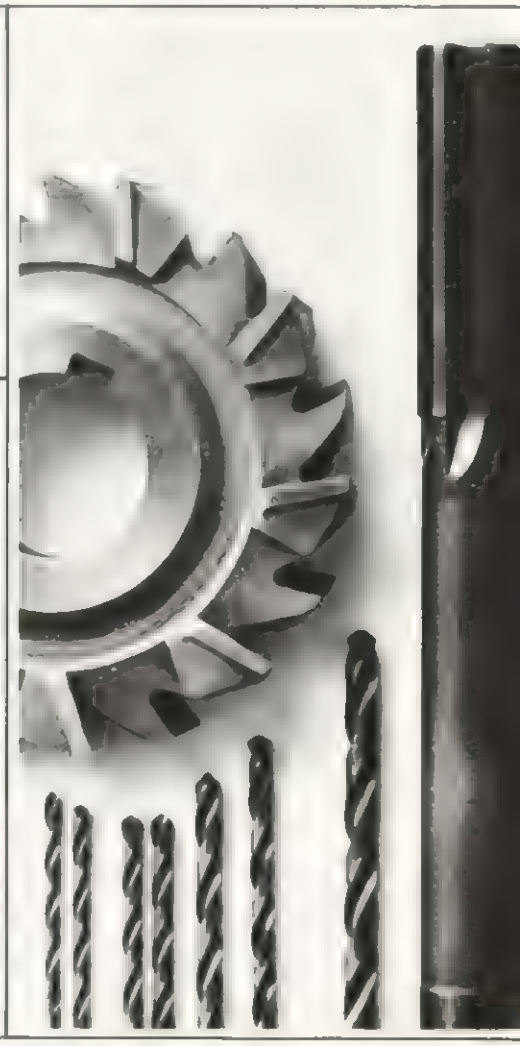




Nuclear Reactor Fuel Tubes



Superalloys



High Speed Steels

Teledyne is heavily involved in electronic navigation systems, as well, with Loran and Omega navigators for long range sea and air navigation, and Raydist systems for precise radiolocation in coastal waters. Doppler radar systems produced by Teledyne were used on 24 successful space landings, and guided each Apollo lander to the surface of the moon. Similar Doppler radars are used in military aircraft for antisubmarine warfare and search-and-rescue missions.

Teledyne avionic instruments and electronic systems contribute substantially to flight safety in both military and general aviation aircraft.

Among Teledyne's many non-electronic products for aviation are controlled explosive devices that precisely time, sequence and actuate aircraft escape systems, and similar pyrotechnic devices used to separate the stages of space vehicles, and to eject or deploy instrument packages of many kinds. Teledyne also produces parachute delivery systems for accurate air-drop of military cargo or emergency supplies.

Precise hydraulic and pneumatic actuating systems and components are made for both fixed and rotary wing aircraft, as are ground support systems such as frequency and power converters and jet engine starters for commercial and general aviation use.

Continental piston engines have been powering airplanes for sixty years, and today about half of the general aviation piston engines produced in the United States are built by Teledyne and used worldwide. Teledyne turbine engines also power remotely-piloted aircraft, military trainers and, in small, expendable versions, provide power for the Harpoon cruise missile.

The company's expertise in airframe manufacture goes back to Charles Lindberg's Spirit of St. Louis which was built by Ryan Aviation, forerunner of today's Teledyne Ryan Aeronautical. More than twenty-five types of remotely-piloted aircraft—usually called RPV's—have been built by Teledyne, in both supersonic and subsonic versions. These recoverable and reusable vehicles are used for sophisticated military missions with the pilots safely flying them from remote control centers. Teledyne is also building the airframe for the new Army attack helicopter and has produced thousands of feet of tapered, roll-formed stringers used in the Boeing 747 and Douglas DC-10 airframes.

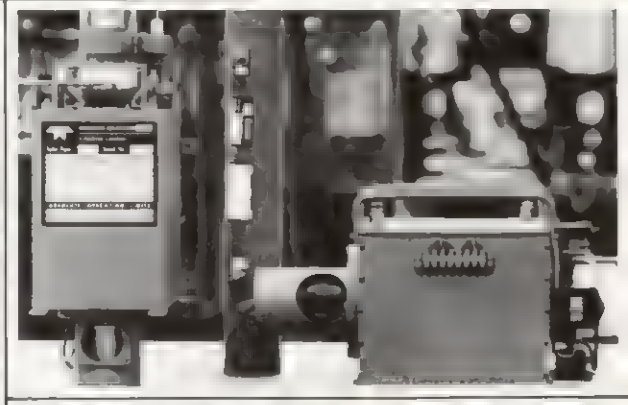
Through the production of sophisticated RPV's Teledyne has also developed broad expertise in the use of advanced materials such as graphite composites, and has facilities for the numerically-controlled machining of airfoils from honeycomb materials.

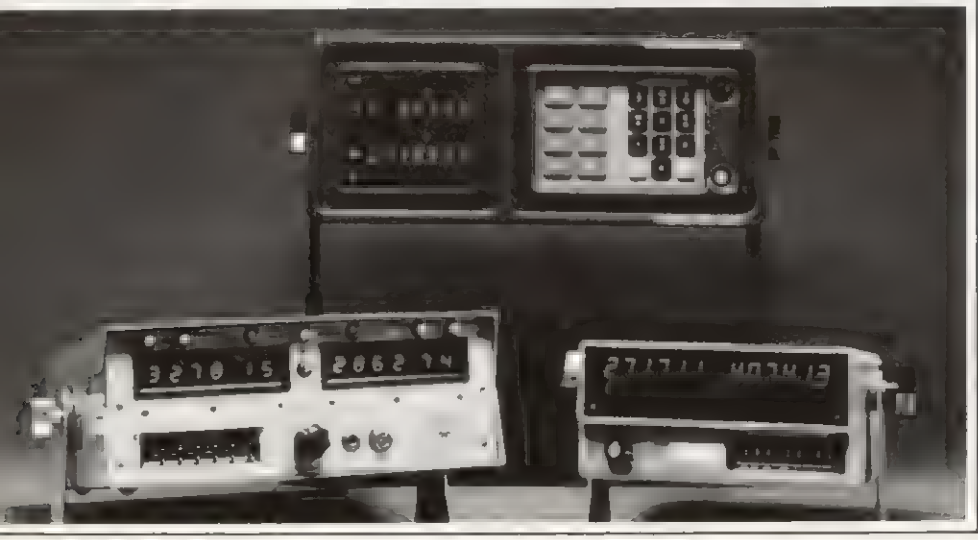
Teledyne's participation in all these diverse areas of aviation, space and electronics has given the company highly developed expertise in some of the most advanced technologies of our time.

Microelectronic Hybrids

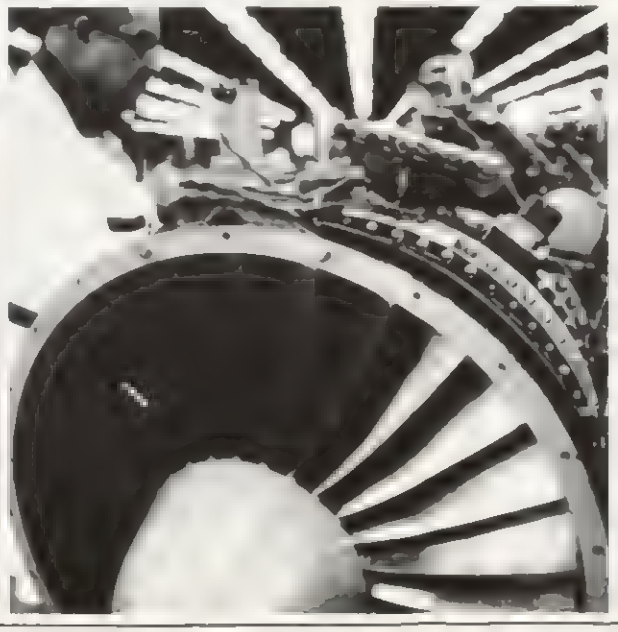
Aircraft Engines

Traveling Wave Tubes





Navigation Systems



Turbine Engines

Consumer & Other Consumer products are a growing and important part of the company's business.

Teledyne's best known consumer products are sold under the brand name Water Pik. The original product in this line was the Water Pik Oral Hygiene Appliance, a device used to cleanse the teeth and gums with a pressurized jet of water. This product has been combined with an electric toothbrush to form a complete family oral hygiene center.

A more recent Water Pik personal care product is the Shower Massage, a showerhead that can deliver a conventional spray or a refreshing jet massage.

Other products marketed under the Water Pik trademark include home security devices, the Water Pik One Step At A Time cigarette smoking withdrawal system, the Instapure household water filter, and a complete infant feeding system for preparing, warming and serving wholesome baby foods, trademarked "The Nurtury."

Teledyne is also well known throughout the world for its line of acoustic suspension high fidelity speakers and record turntables marketed under the AR brand name.

In addition to manufacturing home entertainment products, Teledyne also operates a chain of 79 retail stores in the United States that sell electrical and electronic components, tools, hobbyist supplies and a diverse range of home audio, stereo and video equipment. Some are sold under the private brand names of Teledyne and Olson, and the entire line is also marketed by mail order. Servicing and repair of electronic home entertainment products is also carried out through 40 nationwide service centers.

In an entirely different consumer area are Teledyne Laars swimming pool heaters, and a related line of equipment for heating buildings and supplying hot water for commercial and industrial use.

Teledyne also makes materials and equipment for dentists and dental laboratories. Among these are dental cements, impression compounds, high-speed turbine operated dental handpieces, diamond drilling burs and articulators.

Other miscellaneous products often sold directly to consumers include battery powered lamps, lanterns and emergency lighting equipment, engineering drafting supplies for professional and school use, diazo copying machines, and plastic cups and containers of various sorts.

Insurance & Finance Teledyne's casualty insurance companies write a broad line of insurance including workers' compensation, liability, automobile, homeowners, and fire insurance.

Unicoa Corporation, 95% owned by Teledyne, writes life and health and accident insurance. Fireside Thrift, a consumer finance company, operates in the state of California.

AR Acoustic Suspension Speakers

Retail Electronics

Oral Hygiene & Professional Dental Products

Drafting Equipment & Supplies

Historical Summary

	Consolidated Sales	Net Income	Net Income Per Share	Consolidated Assets	Shareholders' Equity	Average Common Shares
1978	$2,441,629,000	$248,503,000	$19.13	$1,556,990,000	$865,679,000	12,965,787
1977	2,209,731,000	194,783,000	14.81	1,423,757,000	686,475,000	13,033,130
1976	1,937,556,000	136,799,000	9.66	1,207,545,000	495,474,000	13,955,477
1975	1,714,972,000	101,706,000	5.22	1,138,479,000	491,309,000	19,052,119
1974	1,699,987,000	31,505,000	1.12	1,132,913,000	501,793,000	26,149,673
1973	1,455,499,000	65,983,000	2.05	1,232,408,000	537,815,000	31,099,063
1972	1,215,991,000	59,285,000	1.36	1,128,809,000	484,960,000	42,176,100
1971	1,101,872,000	57,425,000	1.27	1,066,772,000	608,118,000	43,663,224
1970	1,216,448,000	61,864,000	1.40	960,607,000	584,349,000	42,745,635
1969	1,294,775,000	58,119,000	1.39	938,133,000	501,961,000	41,139,462
1968	806,747,000	40,289,000	1.13	602,428,000	316,469,000	35,785,451
1967	451,060,000	21,256,000	0.78	336,714,000	152,603,000	27,988,347
1966	256,751,000	12,035,000	0.58	170,369,000	90,205,000	20,658,970
1965	86,504,000	3,402,000	0.32	66,544,000	34,765,000	10,386,896
1964	38,187,000	1,441,000	0.21	35,040,000	13,672,000	6,452,553
1963	31,925,000	731,000	0.12	23,901,000	8,629,000	5,285,740
1962	10,438,000	157,000	0.04	10,844,000	3,527,000	4,188,051
1961	4,491,000	58,000	0.02	3,731,000	2,477,000	3,133,682

As reported in the Company's annual reports, adjusted for dividends and stock splits. 1976 and 1977 were restated to reflect equity accounting. Years 1967 through 1975 were restated for certain accounting changes. Average common shares include common stock equivalents.

Common Stock Price and Dividend Summary*

	1977				*1978*			
Quarters	*1st*	*2nd*	*3rd*	*4th*	*1st*	*2nd*	*3rd*	*4th*
High	61¾	67½	67⅛	58⅝	69⅜	119¾	116	109⅝
Low	49½	48¾	43⅛	45½	52	66⅜	95	83⅛
Dividend	3% Stock Paid in May				10% Stock Paid in June			

**Prices have been adjusted for common stock dividends paid through June 2, 1978. Teledyne Common Stock is listed on the New York and Pacific Stock Exchanges.*

TELEDYNE, INC.

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ROBERT C. JACKSON, *Honorary Chairman, Teledyne Ryan Aeronautical*

GEORGE KOZMETSKY, *Dean of the College of Business Administration of the University of Texas*

GEORGE A. ROBERTS, *President, Teledyne, Inc.*

ARTHUR ROCK, *Private Investor*

CLAUDE E. SHANNON, *Donner Professor of Science at Massachusetts Institute of Technology*

WILLIAM W. SHANNON, *Rancher*

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J. SPENCER LETTS, *Vice President and Secretary*

CHARLES E. RINSCH, *Vice President and Treasurer*

G. WILLIAMS RUTHERFORD, *Vice President*

BARRY J. SHILLITO, *Vice President*

TECK A. WILSON, *Vice President*

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111 Wall Street

New York, New York 10015

TELEDYNE, INC.